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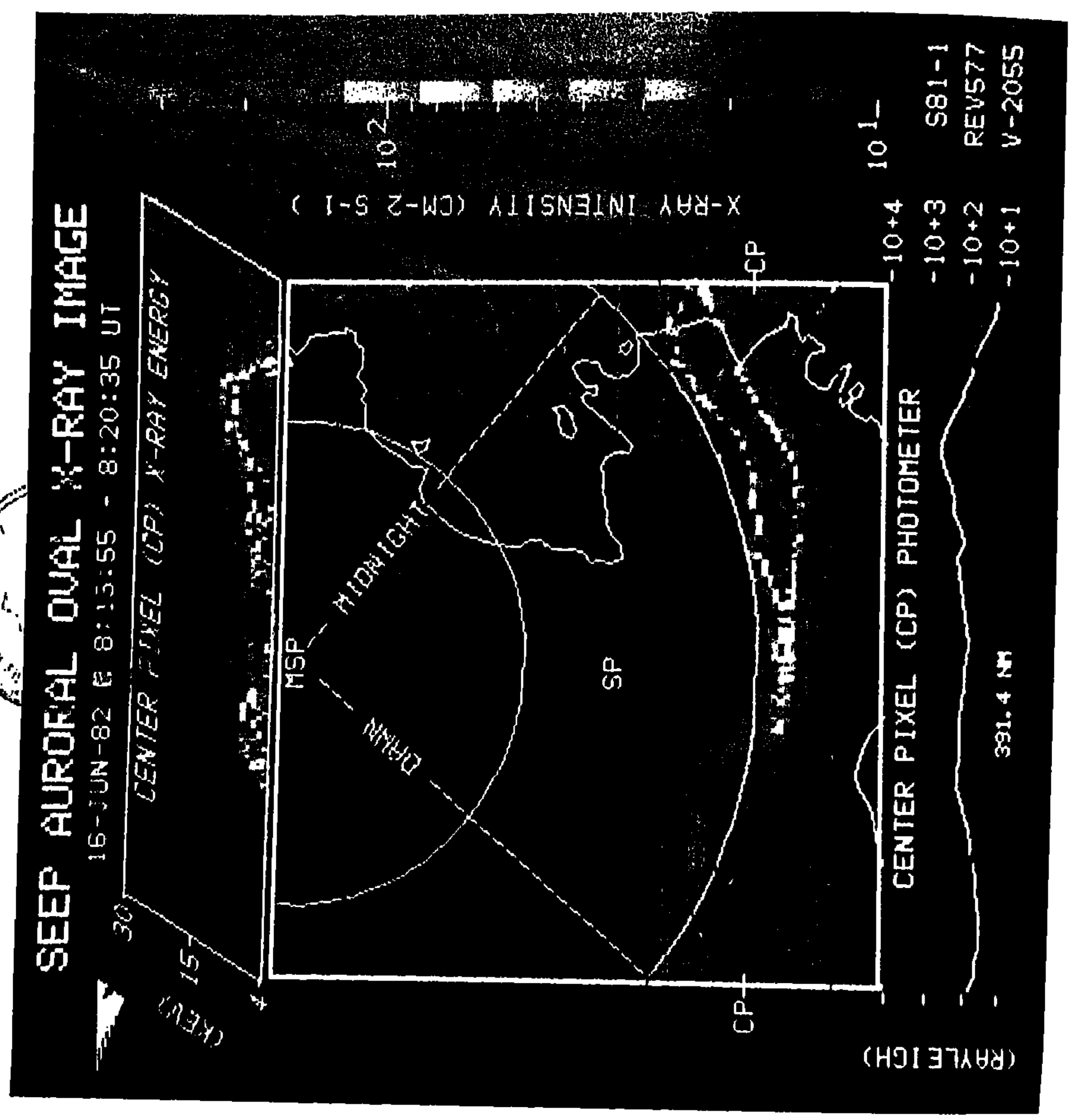


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EOS, Transactions, American Geophysical Union Vol. 64, No. 48, Pages 953–960 November 29, 1983

## Tectonophysics

8150 Tectonophysics (Plate tectonics)
PHANEROZOIC ADDITION RATES TO THE CONTINENTAL CRUST AND CRUSTAL GROWTH
Arthur Reymer and Gerald Schubert (Department of Geology, The Hebrew University of Jerusalem, Jerusalem, Israel)
Phanerozoic addition rates to the continental crust are calculated using seismic profiles through magmatic arcs to measure the crustal volumes added during the active lifespans of the arcs. Data for 17 arcs give addition rates per kilometer of arc in the range 20 to 40 [illegible] (crustal growth, continents, magmatic arcs, Proterozoic crustal evolution).
Tectonics, Paper 3T1679

8199 General or miscellaneous
ACTIVE FAULTING AND TECTONICS OF BURMA AND SURROUNDING REGIONS
Anne Yvonne Le Dain (Laboratoire de Geologie Structurale, Universite des Sciences et Techniques du Languedoc, Montpellier, France)
Paul Tapponnier and Peter Molnar
This study of the active tectonics of Burma and surrounding regions is based mostly on an interpretation of Landsat imagery and on fault plane solutions for shallow and intermediate earthquakes. [illegible] (Active tectonics, Burma, Asia)
J. Geophys. Res., Red, Paper 3B1303





# International Geoscience: Past and Future

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*Editor's Note: The following article is taken from a speech delivered at the 1983 Annual Meeting of the National Academy of Sciences in Washington, D.C.*

The International Geophysical Year (IGY) differed from the preceding international polar years in that it had a significant component of solid earth research. The success of this venture led to succeeding programs, still under way, that have maintained and improved upon the communication mechanisms established during IGY. These programs differed from IGY in that they have a longer time span, usually a decade, and in that they have focused more on the exchange of ideas and data rather than shorter-term, specially funded research programs aimed at particular goals.

To borrow an analogy from oceanography, one might liken IGY to the Challenger expedition of a century ago; a one-shot venture that collected vast amounts of data during a single cruise; data that occupied the energies of a number of scientists over a period of years. The succeeding programs followed more the pattern of modern oceanography in which cruises take place continuously, steadily building the data base and generating new ideas. There is no question but that IGY was a major shot in the arm for solid earth research and it is fair to ask whether it is not time for another such venture. Our support mechanisms have tended to become more narrowly focused on disciplines and subdisciplines through time, reflecting the increasing complexity of science. Perhaps it is time to choose some broad goals: to identify some experiments that require inputs from a number of disciplines and international collaboration in research and that promise us new and better insights into the nature and properties, the history and development of the earth.

I have only read about the International Polar Years, but I participated in the International Geophysical Year. When I think back to it, I am reminded of the comment of Good Fox, a Lakota brave who survived the battle of the Little Big Horn, where General Custer made his last stand. He said, "Hundreds of books have been written about this battle by people who weren't there. I was there, and all I remember is one big cloud of dust." I feel a little like Good Fox, because I was there, but as one of the braves or foot soldiers, not as a chief or a general. I remember the big cloud of dust; dust generated by investigators from many countries who shared an opportunity to investigate phenomena in remote places and to share the results of these investigations through personal contact, through meetings and symposia, through the literature, or through exchange of data.

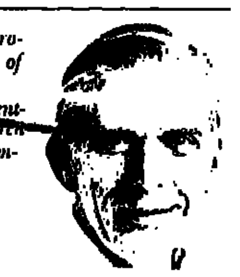
These places were only in part geographically remote, distant parts of the oceans or the polar regions; they also included regions far above the earth's surface, at the bottom of the sea, and in the earth's interior. The solid earth research of IGY included studies of the crustal rocks on the continents and beneath the seas as well as investigations of the deep interior of the earth.

## The Emergence of Plate Tectonics

Maurice Ewing, in a symposium held here at the National Academy of Sciences in June 1957, just prior to the official opening of IGY, noted that "two significant discontinuities, both nearly spherical, divide the earth into three major parts: mantle, core, and crust." Continuing, he identified three major problems that could be considered as the foci for research at that time: (1) the origin of the crust, (2) the mechanics of deformation of the crust, and (3) the possibility of continued exchange of matter between crust and mantle.

As we stand today and look at these foci from the vantage point of plate tectonics, we can be smug and say that we have moved well beyond them; but if we stop and ponder them a bit, we have to admit that some of the mystery still remains. Plate tectonics has given us a very valuable model to which we can relate our data, but has not given us all of the answers.

Plate tectonics has its roots in the distant past; one could argue whether Francis Bacon or Benjamin Franklin or Antonio Snider or Alfred Wegener had the original idea, depending on one's heritage and prejudices.



Charles L. Drake, *professor in the Department of Earth Sciences at Dartmouth College, is president-elect of AGU. His research interests are in geodynamics.*

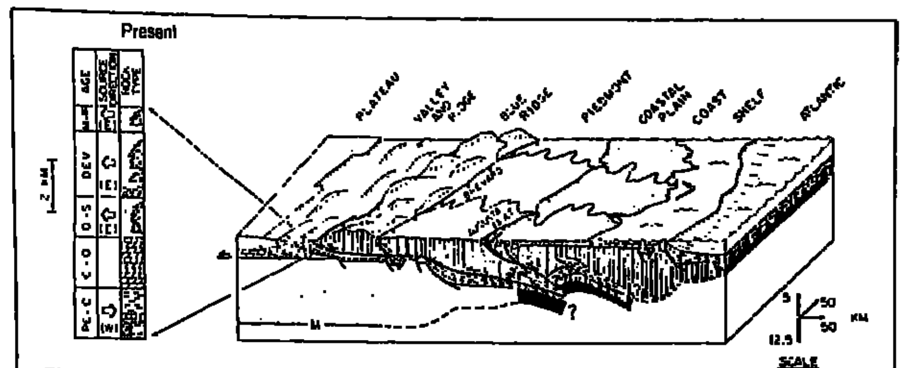


*Fig. 1.* Interpretation of COCORP seismic reflection profile across the southern Appalachians (from *Cook et al.* [1983], reprinted with permission).

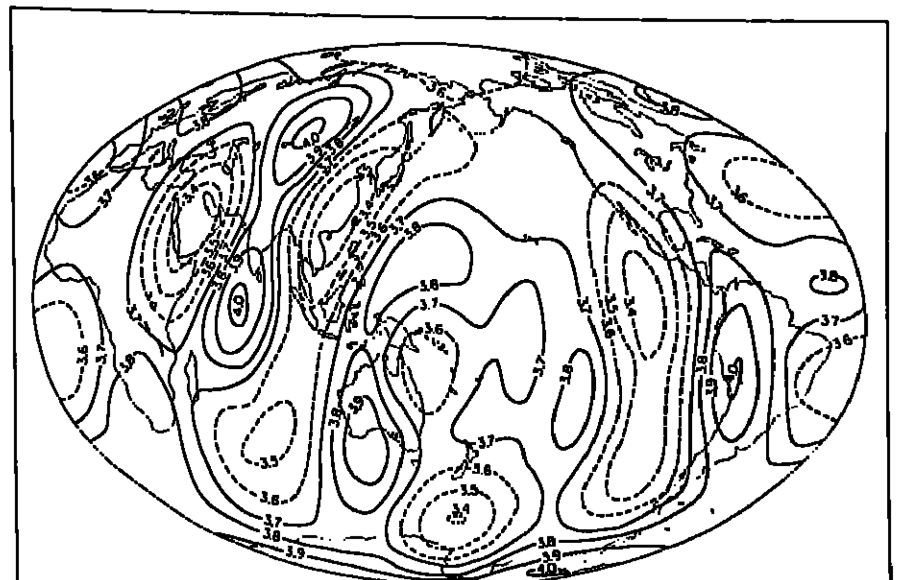


*Fig. 2.* Mantle inhomogeneities developed from digital seismic data. Synthesized group velocity distribution for a period of 152.34 seconds. The interval of contour lines 0.1 km $s^{-1}$. Solid and dashed contours indicate group velocities higher than 3.7 km $s^{-1}$ and lower than 3.6 km $s^{-1}$, respectively (from *Nakanishi and Anderson* [1982], reprinted with permission).

IGY provided some of the fertilizer that brought it to flower. Not only did IGY herald the beginning of the space age, it also marked a major change in studies of the solid earth. It made it possible to explore distant portions of the oceans and the polar regions and it enhanced our ability to probe the secrets of the earth's interior. It brought a global community together to pursue common goals and it created mechanisms for exchange of data and ideas that have persisted to this day. The efforts during IGY helped to establish the continuity of the world ocean ridge system, a major element of plate tectonics; they improved the data base and the ability to analyse surface wave dispersion, and our ability to define the lithosphere, the rigid outer shell of the earth, and the underlying, more plastic asthenosphere, which are also essential elements of plate tectonics.

The success of the collaborative efforts during IGY prompted the solid earth community to establish a new program, the Upper Mantle Project (UMP), for the 1960's. This program, originally organized along disciplinary lines, was focused on the outer 1000 km of the earth, the part in which recognizable tectonic movements take place. It was a special program of the International Council of Scientific Unions (ICSU), administered by the International Union of Geodesy and Geophysics (IUGG), with provision for recognition of the interests of other ICSU unions, especially the newly formed International Union of Geological Sciences.

As UMP developed, it became obvious that special attention needed to be paid to continental margins and island arcs and to the ocean ridge system, for it was in these areas that most of the volcanic and earthquake activity took place. Commissions were formed to coordinate activities in these areas and this represented a move from coordinated research in the individual disciplines to multidisciplinary studies of specific areas or phenomena. It was during the UMP that investigations in several areas led to the development and acceptance of the plate tectonics model. The areas of investigation included magnetism and paleomagnetism, coupled with deep sea drilling and micropaleontology, and seismology, including studies of seismicity, attenuation, surface wave dispersion, and earthquake mechanisms.

The plate tectonics model was responsive to the three major problems about the crust-mantle system outlined by Ewing. It is basically a simple model. It depicts the outer shell of the earth, the lithosphere, as broken into a small number of large plates moving relative to each other and with their boundaries marked by the earthquake zones. They converge along the seismically active continental margins and arcs; they diverge along the axes of the ocean ridges; and they slide along each other in areas like the San Andreas rift zone in California. The model accounts for both the global scale compressional activity in young mountain systems and island arcs and the global scale tensional activity along the ocean ridge system—this concurrent activity was difficult to explain through earlier models.

The model accounts for the origin of the ocean crust, produced along the axis of the ocean ridges and, something Ewing had not anticipated, its destruction as well in the subduction zones. It accounts for the origin and the nature of at least a part of the continental crust although there are many mysteries that remain to be resolved here. The moving plates provide a mechanism that explains many of the deformational features of the earth's crust, although the exact nature of the driving forces that move the plates is still uncertain. It is curious that we rejected Wegener's concept of continental drift because he could not come up with an adequate driving mechanism, but we accepted plate tectonics *despite* the fact that we still lacked a driving mechanism. What we did have was better evidence that the continents had indeed moved relative to each other, geophysical evidence not available to Wegener.

The model also responds to Ewing's third concern, the possibility of continued exchange of matter between crust and mantle. In the original, simple model, it was obvious that the mantle was contributing materials to build new crust and lithosphere along the axes of the ridges and that older crust and lithosphere were returning to the mantle in the subduction zones. These processes appear to have persisted through long periods of time, so it was fair to conclude that the possibility of continued exchange of matter existed.

The plate tectonic model was advanced late in the life of the UMP and was accepted with grace by a very large percentage of the solid earth community. There was enthusiasm for initiating a followup project to develop and test this model. As a result, a new project, the Geodynamics Project, was designed to build upon the discoveries made during the UMP. It was organized as an inter-union program of ICSU, jointly sponsored by IUGG and IUGS and extended through the 1970s. I should note that the national committees for this project were to be jointly organized by the national committees for IUGG and IUGS in participating countries; in a number of these countries this was the first time that these two groups had ever come into contact despite the fact that they were studying the same earth.

The Geodynamics Project viewed the earth as a dynamic body, and though much of the effort was devoted to better definition of the kinematics of plate motions, a good deal was learned about the dynamics of the interior as well, particularly in the ocean areas.

The areas beneath the oceans are geologically young and have, typically, been affected by a single, major tectonic process; hence their development and their main characteristics can be explained in terms of relatively simple thermal models. The continents, on the other hand, contain what is left of 95% of earth history and have suffered multiple tectonic indignities; hence progress in understanding them has been slower. In addition, identification of so-called exotic terranes has led to the conclusion that fragments of the continents have moved great distances before ending up in their present juxtapositions.

Article (cont. on p. 963)

# Editorial

## AGU's Financial Resources

By the end of this year we will have completed the third year of our 5-year appeal to strengthen the financial resources of the Union. Our goal, as presented to and endorsed by the AGU Council at the 1980 AGU Fall Meeting, is to raise $1,000,000. Phrased another way, our goal is to persuade the membership of the Union to invest an additional $1,000,000 in an organization that fully supports their individual efforts in science and is totally concerned about the future of geophysics.

We reported to you last year that we are gaining momentum, primarily due to the support of those members who are making the "voluntary contribution" that is listed on the dues invoices (and sometimes adding a little extra). However, the AGU-GIFT Steering Committee recognizes the need for a greater positive acceleration (the concept can apply to giving as well as to physics) if we are to achieve our goal. We are encouraged by the increasing number of members who contribute at least $80 annually beyond their dues and are thus recognized as Individual Supporting Members. These lists are published frequently in *Eos* (most recently in the November 15 issue). We still believe that within our membership there are individuals who could make substantially larger contributions.

In the initial planning we established the following schedule as a target:

| Number of Members | 5-Year Contribution |
|---|---|
| 5 | $10,000 |
| 50 | $5,000 |
| 60 | $2,500 |
| 100 | $1,000 |
| 300 | $500 |
| 500 | $250 |
| 1000 | $125 |
| 1000 | $50 |

Total: $1,000,000

We are on schedule for the lower part of the table but, as of this date, we are not meeting the upper portion. There is one Benefactor ($10,000 plus) and two Sustaining Members ($5,000) plus one more who is closing in on the $5,000 target. There are also another 14 who have given the $1,500 to qualify as Life Supporting Members. These are the individuals who have recognized the need and have grasped the opportunity to help.

At our last Steering Committee meeting we reviewed the goals and purposes of this appeal. The program was initiated shortly after the AGU headquarters building was purchased with a mortgage that specifies that no advance payments may be made prior to 1986. We recognized that a 5-year window provided ample time to accumulate funds sufficient to pay off the mortgage in 1986 if that seemed financially advisable at that time. Currently we are expending more than $140,000 per year just to pay the mortgage interest plus a small reduction on the principal. Our committee believes that by eliminating the mortgage, this $140,000 line item in the budget could be directed toward greater support of student travel, scholarships, Chapman Conferences, and other educational programs of the Union.

We need the assistance of the leadership of the Union, particularly the Council, in persuading those members who have prospered from their careers in geophysics that a contribution to the Fund is more than an AGU-GIFT—it is a wise investment.

Thanks to each of you for your continuing interest and support.

Earl G. Droessler
Charles A. Whitten
*Co-Chairmen, AGU-GIFT Steering Committee*

*Editor's Note: There is still time to make a tax-deductible contribution in 1983. Use the GIFT pledge card on the back cover.*

# The Oceanography Report

H.M.S. CHALLENGER PREPARING TO SOUND, 1872.

The Oceanography Report
*The focal point for physical, chemical, geological, and biological oceanographers.*

**Editor:** Arnold L. Gordon, Lamont-Doherty Geological Observatory, Palisades, NY 10964 (telephone 914-359-2900, ext. 325).

## FGGE Buoys: 5 Years Later

*John Garrett*

During the final months of 1978 and early 1979 large numbers of small drifting buoys were launched all over the southern oceans in preparation for the First Global Atmospheric Research Program (GARP) Global Experiment. At the time, those of us who had been involved in the preceding years of planning and development were mainly occupied with immediate questions—Would the Argos satellite tracking system work? Would the buoys survive long enough to form a useful array?—but our planning had included concern over the long-term use of the data for oceanographic research. The buoy system worked better than we expected and returned a major data set on the surface currents and temperatures of the southern ocean. Now, 5 years later, it seems timely to review our experience. I will examine what we learned about the potential of drifting buoys and how our experience may help us to plan future large-scale observing systems of all types.

### History

By the mid 1960's it was recognized that the absence of a global atmospheric data set would ultimately be a limiting factor in determining and exploiting the predictability of atmospheric motions. This recognition led the Joint Organizing Committee on GARP to plan for a global meteorological experiment, which became known as the First GARP Global Experiment (FGGE). One area of great concern was the southern hemisphere, where the large expanse of ocean led to a very low density of conventional meteorological observations. Although satellite technology was still fairly new, the idea of using orbital satellites to track automatic platforms and collect their data had already been proposed, and systems using inexpensive transmitters were on the drawing boards in the United States and France. Although the initial objectives of both the French Eole system and the U.S. Nimbus RAMS system were the tracking of constant pressure balloons, it was quickly obvious that the light, low power balloon transmitters could be used on small floating buoys. This gave rise to the idea that a system consisting of free-drifting buoys measuring surface pressures together with constant-pressure balloons giving wind data at one or more levels might provide the required information from the southern hemisphere.

The French balloon group stimulated buoy activity by making some buoys and balloon transmitters available to oceanographers in early 1972. Although the first balloon transmitters proved too fragile to survive long at sea, oceanographers were not slow to see the possibilities of a system in which a buoy powered by 20 kg of batteries could be followed for up to a year. Enthusiasm for the Nimbus RAMS system, with its comparatively low-cost transmitters, led to the initiation of drifting buoy programs in Australia, Canada, France, South Africa, and the United States.

Thus in 1974, when planning began in earnest for the FGGE system, there was some experience with satellite-tracked drifting buoys which, combined with parallel experience with small meteorological buoys, suggested that the system was feasible. However, there were serious fears that barometric pressure observations could not be made to the required accuracy by any automatic station unattended for a year, even if it were not mounted on a small buoy. It was also clear that achievement of buoy lifetimes long enough to make the project practical would tax the limits of our engineering capabilities. Nevertheless, optimism prevailed, development programs were established in several countries, with early positive results, and planning proceeded.

One element beyond the control of the buoy group gave rise to great concern: the use of a new, untried satellite tracking system, which was scheduled to replace the Nimbus RAMS system only a few months before the actual experiment was to begin. Although the transmitter design would be similar to those in use, any change seemed likely to adversely affect its reliability, which was expected to be the factor limiting buoy life. Also there was the risk that the new system might not work at all. The planned launch date of the new system was too late to permit any major redesign or to correct faults in the buoys. However, this risk had to be accepted, although we were very unhappy when the satellite launching was delayed until only days before the first buoy deployments, and after many of the buoys were already on ships at sea. It was a great relief when the Argos system worked nearly perfectly from the moment it was turned on!

During the preliminary planning process scientists with experience in southern hemisphere oceanography were invited to participate. Several attended early meetings, but their interest seemed to diminish when it was found that the limited number of buoys available would result in separations on the order of 1000 km to cover the area for which meteorological data was required. For some reason the idea of supplementing meteorological funding with oceanographic funding to increase the density of the array in selected areas was never seriously proposed, although hindsight suggests that this would have been a valuable thing to have done. However, the oceanographic priorities of the day were elsewhere.

The organizational framework for the buoy system was based on national programs, which were coordinated to ensure that the measurement specifications were met and that the buoy deployments were optimized to produce the most nearly uniform possible array. The committee held only five formal meetings, one of which was a critical review at the end of the experiment, but small, full-time centers were set up to coordinate the deployment and to prepare the delayed time data set.

The 369 buoys were launched by a collection of vessels, including research ships, Antarctic supply vessels, military vessels, commercial ships, and even a longboat from Pitcairn Island. Aircraft were also successfully used to deploy buoys in the Arctic and in the southern ocean. The deployment plan was designed to produce optimal coverage (1000-km-grid) during the special observing periods of January-February and June-July 1979. To allow for the unknown buoy lifetime, the array was deployed gradually between November 1978 and July 1979. The planning was remarkably successful, as shown by the fact that 70% of the ocean between 20°S and 65°S was within 500 km of a working buoy from April until September 1979.

Data were collected and distributed from the buoy array between November 1978 and May 1981, although the number of buoys declined steadily after June 1979, when there were 236 transmitting from the southern ocean. These data were distributed within a few hours for use in operational meteorology and oceanography. They were also archived for future research use, after a quality control process based on comments received from the operational data users. The archived data for the FGGE operational year (November 1978–December 1979) have been available since July 1981 and those for the following year since January 1982 [*Garrett*, 1980]. A companion report which reviews the performance of every buoy is also available to assist in decisions regarding data quality [*World Meteorological Organization*, 1980]. Temperature maps produced using that real time data set were distributed during the operational year and have been compiled into a report [*Keeley and Taylor*, 1982].

### Oceanographic Results

Within a few months, the real time data that appeared in several publications showed that the buoy data were in general agreement with conventional thinking on the circulation of the Southern Ocean [*Kort*, 1981; Meincke, 1980] while others used it for regional studies [*Lutjeharms et al.*, 1981]. Although some preliminary reports based on the full, archived data set have appeared [*Garrett*, 1981], more complete studies have been delayed by the sheer volume of data. A few groups are currently working on different problems using the data, and publications are to be expected in the next few months.

My own work suggests that the oceanographic potential of the buoy data is very high. Maps of mean buoy drift velocities averaged over 300-km cells resemble established ideas of the general circulation and show significant correlation with surface currents computed from dynamic heights. Linear regression coefficients between buoy speeds and currents computed from dynamic heights have the values that would be expected from the computed profiles of baroclinic shear. However, there are important differences between the buoy mean currents and those deduced from density data related to the fact that the buoy data were collected over a considerable period of time while a typical oceanographic cruise produces a more or less instantaneous view. In many respects the most interesting aspect of the buoy data is in the distribution and magnitude of the variability of the drifts. Maps of mesoscale variability show maxim associated with the return flows of western boundary currents, and with places where the Antarctic Circumpolar Current crosses meridional ridges. This distribution agrees reasonably well with maps of "eddy kinetic energy" obtained from ship drifts and satellite altimetry, and also permits other types of analysis to examine the nature of the motions involved. In most areas the variance of the currents is large enough that the statistical reliability of the estimate of the mean is small, particularly for the north-south component, which raises some important questions for programs trying to measure meridional transports. The mesoscale velocities are nearly isotropic, i.e., meridional and zonal components contain nearly equal energies. The spectra of the buoy velocities between scales of 300 km and 50 km show a power-law dependence approximately proportional to the −5/3 power.

It seems obvious that the buoy motions would be directly affected by the wind, but it turns out to be difficult to isolate such effects, suggesting that they do not play a major role in controlling buoy drifts. In some regions the buoy tracks are highly reproducible over periods of several months. The mean and eddy kinetic energy fields contain regions of comparatively low values which are smaller than variations in the average wind stress. Time lag correlations of the velocities of buoys passing through individual points show significant correlations after lags of a few weeks, longer than the time scale of wind variations. In fact, the apparent weakness of the buoy response to the wind is perplexing since the buoys are embedded in the upper mixed layer, which is itself expected to respond to the winds.

Reports by the meteorological users of the data indicate that the buoys permitted a significant improvement in the description of the wind field, which also has considerable interest from the oceanographic point of view.

### Conclusions

It took something more than 10 years to go from the inception of the idea through the development of the satellite systems to the point where the buoy array was successfully implemented. The actual buoy development specifically directed toward the FGGE array took place only in the last 4 of those years, but they were very busy ones and depended heavily on earlier results. Another year would have been welcome to allow proper testing with the Argos system, but constraints imposed by other elements of the overall FGGE would not permit this. Allowing for budgetary cycles, this means that the agencies involved made commitments to the program at least 5 years before the experiment was actually scheduled to take place. The necessary long time scale effectively restricted participation to government agencies. At the time that commitments were required, the oceanographic significance of drifting-buoy measurements of surface currents was not well accepted, so oceanographers were reluctant to become involved in such a risky venture. This left control of the experiment to meteorologists and meteorological agencies. Fortunately these agencies took care to ensure that the oceanographic value of the data was conserved as much as possible, but there is no guarantee that this would happen in planning for future observing systems.

It is surprising and somewhat disappointing that there has not been more effort to exploit this freely available data set. One possible explanation is that it is still too soon for its value to be widely recognized, and that interest will be aroused by the publication of a few papers. Another is that oceanographers are not particularly interested in data they have not themselves collected. The planners of future large-scale programs, where the data obtained are expected to have a utility wider than the specific objective of the program, should be aware that the secondary users may not automatically and immediately recognize the value of the results being handed to them. The delay in recognition of the value of the data has led to a delay in setting up systems for archiving other drifting buoy data, so that its pointed utility in climatological studies is diminished.

Most of those involved in the planning and implementation of the FGGE buoy array believed that its success would lead to the continuation of some sort of buoy array on a nearly permanent basis. This was expected to provide a climatological data base and also the opportunity to incorporate improved oceanographic sensors as they became available. In spite of the technical success achieved, only a small number of buoys are currently being deployed each year in the southern ocean. The explanation for this lies partly in the global economic decline, and partly in the length of the funding cycle. In order to set up a buoy network, national meteorological agencies would have to discontinue some already established type of observation.

Close study of the FGGE buoy data set serves to increase one's appreciation of some unsolved problems of oceanography. One example is our inability to estimate the wind effect on buoy drift, which also makes it evident that we don't really know what should be the Lagrangian drift of a water "particle" in the upper layer. The definition of "mean currents" and the estimation of "mean transports" become problematical in areas of high variance of velocity associated with mesoscale motions. The bottom topography is clearly important to the mesoscale eddy activity in the southern ocean, but the present level of theoretical understanding seems unable to deal adequately with this fact.

A member of our external review committee recently asked me whether I considered the time put into the planning and coordination of the FGGE system to have been well spent. My response was that it had been very satisfying indeed to have been part of something that worked better than anyone really thought possible and that the spirit of genuine cooperation which prevailed had altered my view of human nature, but that I would feel much better about my efforts when I knew that there were lots of people busily using the data in their research. I suspect this feeling is common among those involved in large data-collection exercises. I also suspect that many potential data users delicately hold back so as to allow the organizers to have the first crack at the data, thus frustrating those very organizers. Thus one of the messages I would like to convey is that it is possible to improve large experiments by contributing to the planning, but even when it is too late for that the data probably contain more information than conventional wisdom suggests, and the people who collected it would be only too happy for others to use it.

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# Information Report

## Climatological Atlas of the World Ocean

A project to objectively analyze historical ocean temperature, salinity, oxygen, and percent oxygen saturation data for the world ocean has recently been completed at the National Oceanic and Atmospheric Administration's (NOAA) Geophysical Fluid Dynamics Laboratory, Princeton, New Jersey. The results of the project are being made available through distribution of the *Climatological Atlas of the World Ocean* (NOAA Professional Paper No. 13), and through distribution of magnetic tapes containing the objective analyses.

The sources of data used in the project were the Station Data, Mechanical Bathythermograph, and Expendable Bathythermograph files of the National Oceanographic Data Center (NODC) in Washington, D. C., updated through 1977–1978. The raw data were subjected to quality control procedures, averaged by one-degree squares, and then used as input to an objective analysis procedure that fills in one-degree squares containing no data and smooths the results. Due to the lack of synoptic observations for the world ocean, the historical data are composited by annual, seasonal, and (for temperature) monthly periods.

Annual mean, objectively analyzed fields of temperature, salinity, oxygen, and percent oxygen saturation were produced at 33 standard oceanographic analysis levels from the sea surface through a depth of 5500 m. Seasonal mean, objectively analyzed fields of temperature and salinity were produced at 24 standard levels from the sea surface through 1500 m depth. Monthly, objectively analyzed fields of the potential temperature were produced at 19 standard levels from the sea surface through a depth of 1000 m.

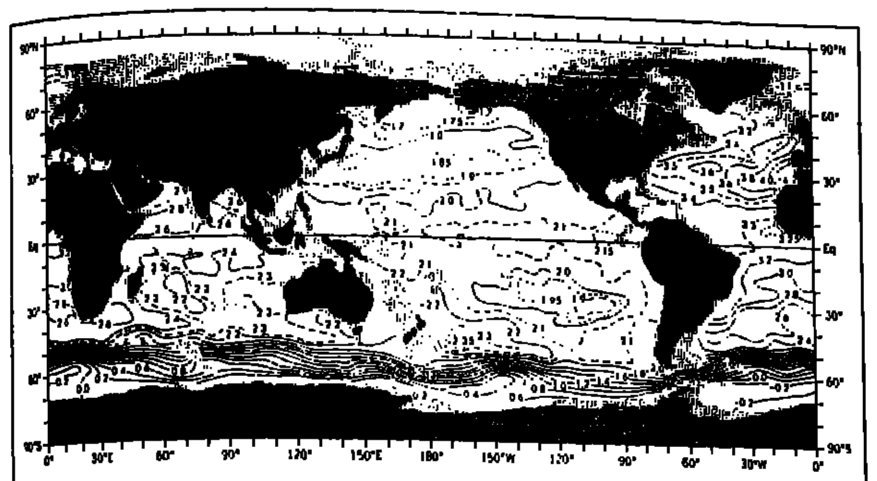

*Fig. 1.* Potential temperature (°C) at 2000-m depth.

Details of the processing of the data and their distributions in space and time appear in the atlas. Results are presented in the atlas in several ways. Contoured horizontal maps of the analyzed fields are given, as well as zonal averages of these fields over individual ocean basins. Maps of derived quantities such as geopotential thickness, Brunt-Väisälä frequency, and mixed-layer distributions are also presented. Basin means of the analyzed fields are presented in both tables and figures. An example of one of the standard-level analyses, the field of potential temperature at 2000-m depth, is shown in Figure 1; dissolved oxygen at 1500-m depth is shown on the cover. The relatively large meridional temperature gradient centered at approximately 55°S is associated with the flow of the Antarctic Circumpolar Current. The injection of relatively warm Mediterranean water into the north Atlantic is quite apparent. The atlas also contains discussions of the various maps and figures.

A packet containing 17 microfiches, attached to the atlas, provides three types of information: (1) computer contoured maps of all standard-level analyses for the annual mean fields, as well as the standard-level analyses of temperature and salinity for the upper 250 m of the water column for each of the four seasons; (2) maps of the distribution of temperature, salinity, and oxygen observations by one-degree squares at selected standard levels and averaging periods; and (3) statistics (number of observations, mean, and standard deviation) by five-degree squares of temperature, salinity, oxygen, percent oxygen saturation, potential density, and anomaly of specific volume.

The data used in computing these statistics are the quality-controlled observations used to compute the one-degree square means that served as input to the objective analyses. These statistics are presented for all standard levels for the annual period and at all standard levels in the upper 250 m of the water column for each season.

Copies of the atlas (#003-017-00509-7) are available for $11 from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 (tel.: 202-783-3238).

Magnetic tapes containing the annual mean analyses (two tapes) and the seasonal analyses (four tapes) are available at $110 per tape. A flier giving details about the data sets and tape formats is available on request from NODC, User Services Branch, NOAA/NESDIS/EOC21, Washington, DC 20235.

*This report was contributed by Sydney Levitus, who is with the NOAA Geophysical Fluid Dynamics Laboratory, Princeton University, Princeton, NJ 08542.*

**Article** *(cont. from p. 961)*

## Questions Raised by Plate Tectonics

The plate tectonics model answered many questions and, as expected, revealed many new ones. At the beginning of IGP, future research on the thermal state of the earth's interior seemed to require reliable ways of estimating the temperature profile; now, with a convecting earth, the present thermal regime is not rigidly tied to cosmology; instead the boundary conditions appear to be tied to plate motions.

We have come to accept that ophiolites, an association of ultrabasic rocks, pillow lavas, and deep sea sediments defined by Steinmann early in this century, represent the remnants of ancient ocean crust and mark the sutures between former fragments of continents now glued together. The absence of this trinity in very ancient rocks has raised questions in the minds of many about the applicability of the modern plate tectonics model to the earlier history of the earth.

Studies of the ocean ridges and crust have revealed that exchange of materials between crust and mantle is more extensive and takes place at more rapid rates than previously thought. Sea water circulates actively through the crust of the ocean ridges. This not only produces polymetallic sulphide deposits at rates which come dangerously close to making these renewable resources, but it alters the ocean crustal rocks as well. Hydrothermal circulation may affect as much as one third of the ocean crust and subduction of this crust, possibly together with sediments, returns ocean water to the mantle. Fyfe has estimated that the ocean mass recycles through the mantle about once every billion years or in half that time if pelagic sediments are also subducted.

From ice cores from boreholes in Greenland and Antarctica, through deep sea drilling, and through geological studies on land, we are beginning to understand the nature of climate variations in the time frame of thousands to many millions of years, variations due to both internal and external forces acting on the earth.

The satellite observations begun to study the ionosphere and the magnetosphere during IGY were extended to provide data about the solid earth and the terrestrial planets. These observations have not only provided exciting new data about the earth, but have proved to be of great value in understanding its early history, the first 600 million years for which no evidence has been found in the geological record.

Rocks brought back from the moon date back almost to the beginning of earth history. Direct examination of these rocks and of images from other terrestrial planets together with geochemical and geophysical data derived from the earth's interior have allowed us to reconstruct this early history and to draw inferences about why the earth is the only one of these bodies with a plate tectonic history. The delicate geochemical techniques developed for study of the moon rocks have proved invaluable when applied to the earth.

The margins of the continents are especially significant areas because they reflect the rifting or the subduction or collision processes that are integral to plate tectonics. Unfortunately, they are divided by a coastline and the techniques used to study the land and the water covered areas are different and are used by different communities. Through joint programs extending from pure ocean to pure continent considerable progress has been made in understanding these, the major discontinuities in the crust (see Figure 1).

The continents themselves have not been well explored except in the near surface, but through deep seismic reflection measurements we are beginning to see the complexity of the lower crust and the upper mantle and to appreciate that our cartoons of the geology as depth, projected from near surface investigations, are often just that, cartoons.

The Geodynamics Project has been succeeded for the 1980's by a new program, the Lithosphere Project, which has only recently begun. This project recognizes that to understand the history and structure of the crustal rocks, one must understand the nature of the lithosphere, how it developed through time, the chemical reservoirs that contribute to it or to which it contributes, and the processes that have affected and continue to affect it. A major thrust of the project is to define what the lithosphere actually is. It may seem odd to name a project after something that is ill defined, but Professor Belousov, some years ago, in reference to the poorly defined upper mantle, remarked that this gave people a lot of running room; it did not put an artificial limit on possible research. The lithosphere was originally defined around the turn of the century on the basis of rheology; its base was where lateral flow could take place to maintain isostasy. It can also be defined by thermal data or various kinds of seismic information, and none of the definitions are quite the same.

Another main thrust is to better understand the continental lithosphere which contains what remains of 95% of earth history. This should not imply neglect of the oceans, for it has been through processes acting beneath the oceans and around their margins that much, maybe most, of the lithosphere has been constructed. Nor does it imply neglect of the earth's interior since this is the source of the energy that drives the geodynamic system and of the materials that make up the crust and the rest of the lithosphere.

### Potential Benefits of a New IGY

Through the international activities mentioned above: through the International Geological Correlation Program of IUGS and UNESCO, which makes it possible for geologists of many countries to get together on projects of mutual interest; through scientific ocean drilling; and through the Decade of North American Geology of the Geological Society of America, designed to produce by 1988 a series of modern maps and volumes on the geology of North America and its margins—through these projects it might appear that the solid earth people have about all of the international and interdisciplinary activities that they can stomach. Why, then, think in terms of another IGY-type program?

One reason is the large experiment. For example, we really don't know much about the continental crust. We examine the surface rocks and try to work out the structure; we examine the deeper crustal rocks where they have been flung out by diatremes, volcanic vents; we use remote sensing techniques to probe within the earth to determine its character; we look at it on a large scale from space (see Figure 2). Only recently have we had tools sharp enough to give us any kind of detail about the deep crust and upper mantle. When we look at the detail, we find that the relationship between surface geology and deep structure is not quite as simple as might be assumed.

The Soviets decided some time ago to look at the deeper crust first hand and for some years they have been drilling a deep hole through the ancient crystalline rocks of Kola Peninsula. It is planned for 15 km and is currently at about 13 km. This hole has revealed a number of surprises. It drilled through a discontinuity identified by seismic refraction measurements, the Conrad discontinuity, but no changes in density, seismic wave velocity, or other physical properties were detected at that depth. Gases and inflows of strongly mineralized waters have been encountered throughout the hole, even at depths below 10 km, where common wisdom would suggest that the pores should be closed. Metallic sulphides were found at depths of 9.5 km. The temperature gradient was quite different from that expected, and they report that the contribution of heat from radioactive decay within the rocks penetrated by the drill appears to be insignificant.

A continental scientific drilling program has been proposed in this country to complement the highly successful ocean scientific drilling program. The initial emphasis has been placed on holes of opportunity—holes drilled for other purposes—and this venture has been quite successful. But the time is approaching when dedicated holes will be required in well-explored areas to answer questions

**Article** *(cont. on p. 964)*

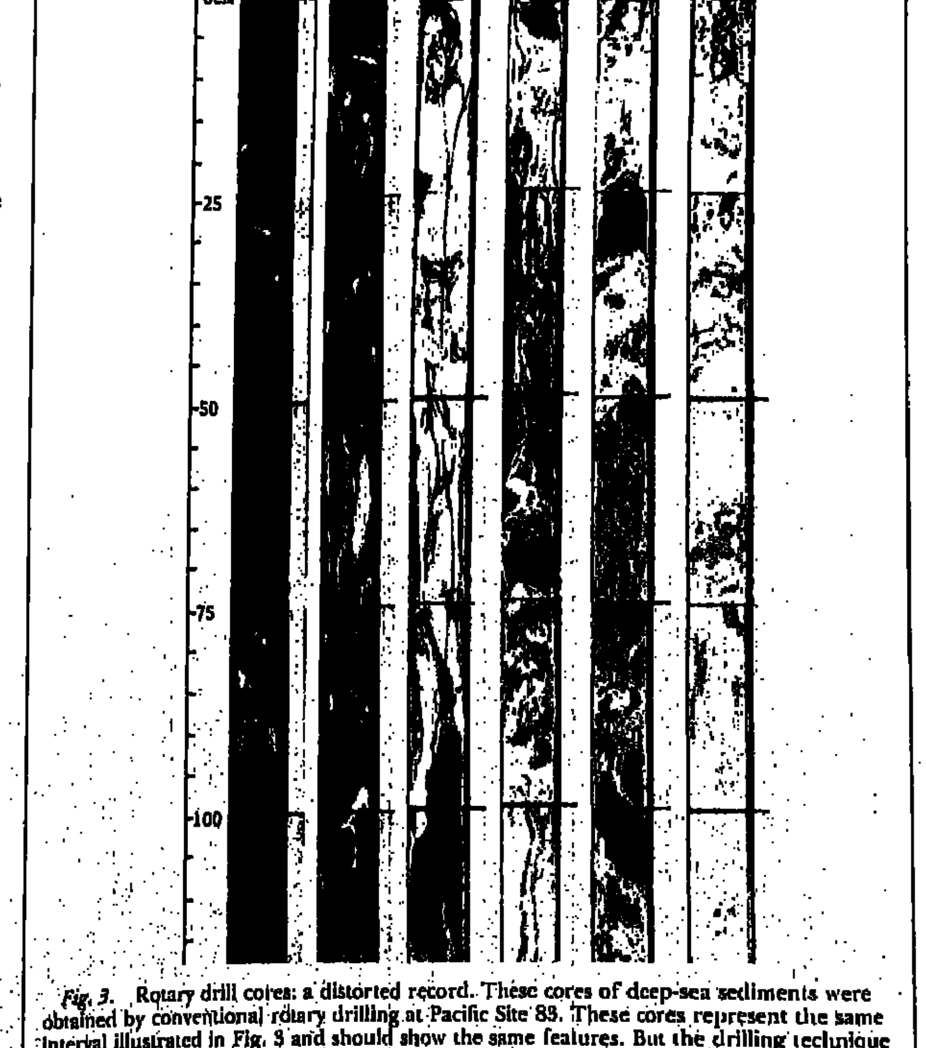



*Fig. 3.* Rotary drill cores: a distorted record. These cores of deep-sea sediments were obtained by conventional rotary drilling at Pacific Site 83. These cores represent the same interval illustrated in Fig. 3 and should show the same features. But the drilling technique has grossly disturbed the sediment, as evidenced by near vertical layering, flow patterns, and distorted burrows (photo courtesy of John Imbrie).

**EOS**

**Transactions, American Geophysical Union**

*The Weekly Newspaper of Geophysics*

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Cover. Dissolved oxygen (milliliters per liter) at 1500-m depth, from NOAA's new *Climatological Atlas of the World Ocean*. See The Oceanography Report, this issue.

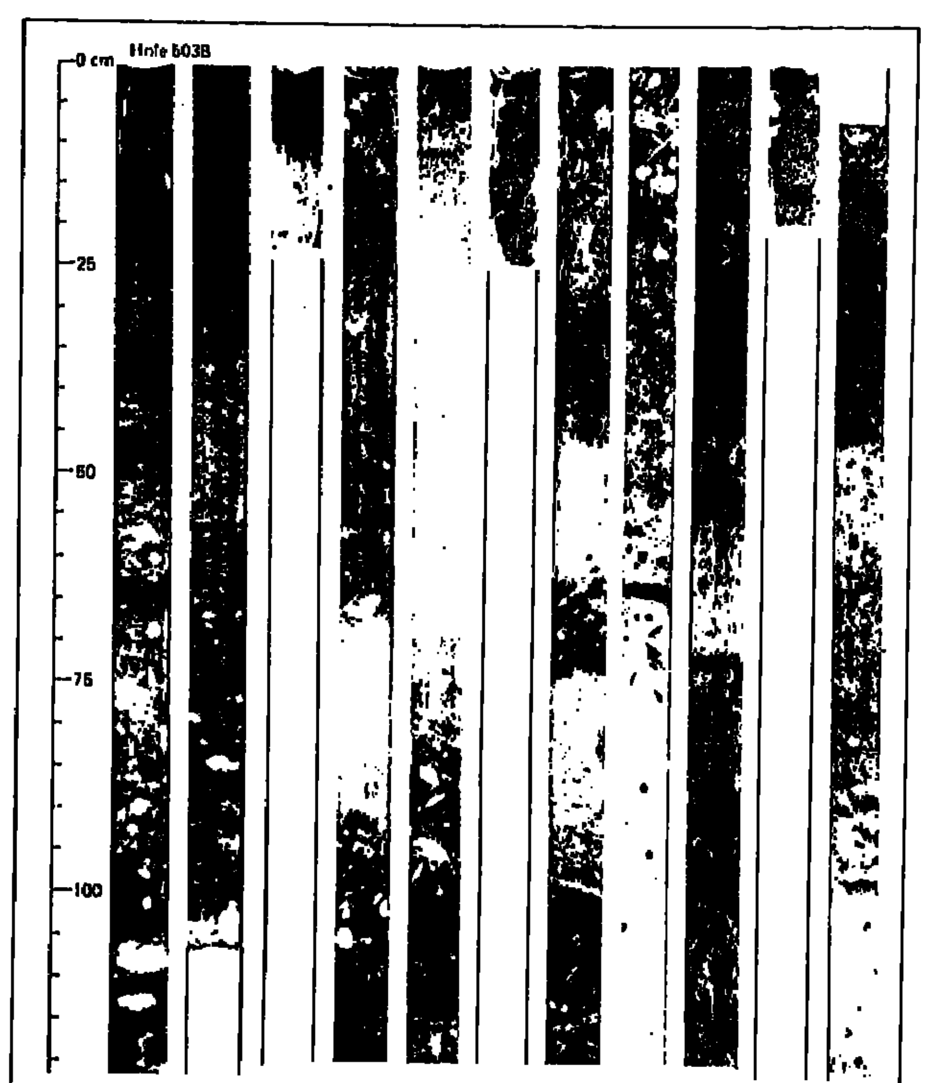


*Fig. 4.* Hydraulic piston cores: an undistorted record. These cores of deep-sea sediments were obtained by hydraulic piston coring at Pacific Site 503B. Note the discrete, cylindrical worm burrows and the horizontal contacts between different layers—features which indicate that the samples contain an undistorted record of earth history (photo courtesy of John Imbrie).

**Article** *(cont. from p. 963)*

tions about the thermal regimes in the crust; the movement of mineralized fluids and the processes through which mineral deposits are formed; the processes related to earth deformation and earthquakes; and the nature and history of the ancient crust. The costs of deep, dedicated holes are large, and considerable geological and geophysical data will be required to select suitable sites for drilling. A major thrust to better determine the nature of continental crust and the processes affecting it would have a great deal of merit as part of a large future program.

Another reason might be to focus on a specific question, such as the transfer of energy and matter to and from the solid earth on time scales that are of interest to the biologists, the oceanographers, and the atmospheric scientists. We do not have a very good grip on the magnitude and composition of the materials that are being ejected by the solid earth into the atmosphere or the oceans nor of the rates at which this happens. Similar uncertainties exist with regard to the nature of the materials being returned to the interior of the earth in the subduction zones.

On top of this, it has been suggested in recent years that extraterrestrial inputs of energy and matter may have had significant impact on the earth's environment and life and the evolution of that life. Major experiments to better define the fluxes of energy and matter into and out of the solid earth could be a fundamental part of a new international program. It goes without saying that suitable locations for such experiments would be geographically diverse, on land and at sea.

Still another reason might be to improve our ability to measure time. A century ago there was a consensus among paleontologists that the time required for observed organic evolution was of the order of hundreds of millions of years. But then, Lord Kelvin, on the basis of then-known sources of energy, calculated that the earth had been habitable for only a few tens of millions of years. This caused some panic, but it was resolved by the discovery of radioactivity. This not only provided a new source of energy, not considered by Kelvin, but it also provided methods for absolute dating of the rocks. In this case, the paleontologists won over the physicists.

Now we face a new controversy, one that suggests that short-term, singular events, such as impacts of extraterrestrial bodies, may have played a major role in the evolution of life. This suggestion is coupled to the question of whether evolution is gradual or punctuated, whether we are dealing with the survival of the fittest or, perhaps, the survival of the luckiest. We again have a problem with time, in this case with how *well* we can measure it. Fossil chronology was calibrated against radioactive dating and, more recently, magnetic stratigraphy has given us a way of determining comparative age in favorable locations to within, say, 10,000 years. This is very good in terms of a geological time scale of 4.5 billion years, but it is tantalizingly far from being good enough to resolve major questions about the effect of large, geologically instantaneous events on organisms or on the global environment. Our tools are getting better and new methods for time discrimination are being invented. It remains to be seen whether the paleontologists or the physicists will win this one (see Figures 3 and 4).

Time discrimination is fundamental to the measurement of rates. We conclude, from the record in the rocks, that formation of new crust at the ridge axes takes place at rates of centimeters per year, but we don't know whether this takes place rapidly or intermittently because we look at the integrated result of processes operating over a long period of time. We haven't actually measured plate motions yet, but some of the new space techniques show promise of being able to do so. A focus on improving time resolution could help us to resolve some of the major questions about processes and the rates at which they occur.

I have aired a few of my own prejudices and, knowing my colleagues in the solid earth sciences, I do not think that they would be shy about offering a few more. Most of the post-IGY programs that I mentioned earlier have had few physical resources specifically at their disposal; they depended upon the normal, discipline-oriented support systems. I believe that a well-designed program of research, focused on a limited number of principal objectives and marshaling, for a period, the proper human and physical resources, could result in significant advances and that these advances could be speeded through interaction and collaboration with our colleagues in other countries.

King Hubbert said in a recent interview that the importance of any science, socially, is its effect on what people think and on what they do. With reference to geology, he noted that in the period beginning about two centuries ago, people like Hutton, Lyell, and Darwin influenced how people thought; they gave us a geological view of the history of the earth rather than a Biblical one. Then, in the period beginning about a century ago, geologists became more utilitarian, concentrating on the search for resources. They influenced how people lived. Now, at present, perhaps it is time for geologists to again become a major force in how people think, rather than how they live.

How we think about the earth depends upon our perception of the earth. One of the striking contributions of the space probes of the 1970's was their photographs of the earth from space, which made it clear to anyone who looked at them the finite size of the earth. This appreciation was sometimes accompanied by apprehension that its finite size was coupled with a limited carrying capacity as a life support system. These apprehensions were not without foundation, but it is hard to conclude what this carrying capacity is when we have not yet been able to quantify or to fully understand the many phenomena and many interactions and feedbacks among these phenomena. We who study the earth, its waters, its atmosphere, and its place in the solar system can respond to Hubbert's challenge by striving for better understanding of these phenomena and these various interactions; by providing a solid scientific base upon which perceptions, and decisions, can be based.

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# News

## Computer Proposals

To expand the research community's access to supercomputers, the National Science Foundation (NSF) has begun a program to match researchers who require the capabilities of a supercomputer with those facilities that have such computer resources available.

Recent studies on computer needs in scientific and engineering research underscore the need for greater access to supercomputers (*Eos*, July 6, 1982, p. 562), especially those categorized as "Class VI" machines. Complex computer models for research on astronomy, the oceans, and the atmosphere often require such capabilities. In addition, similar needs are emerging in the earth sciences: A Union session at the AGU Fall Meeting in San Francisco this week will focus on the research computing needs of the geosciences. A Class VI supercomputer has a memory capacity of at least 1 megaword, a speed of upwards of 100 MFLOPS (million floating point operations per second), and both scalar and vector registers in the CPU (central processing unit). Examples of Class VI machines are the CRAY-1 and the CYBER 205. The high costs of these machines, the most powerful ones available, preclude most research facilities from owning one.

Impetus for the program comes from the recent report by the Panel on Large Scale Computing in Science and Engineering, commissioned by NSF and the Department of Defense and chaired by Peter D. Lax. The panel said that although the United States has been and is the leader in supercomputer technology, "this position of leadership is seriously undermined by the lack of broad scale exploitation, outside of a few national laboratories, of the scientific and engineering opportunities offered by supercomputing, and by a slowdown in the introduction of new generations of supercomputers."

As a result of this report and of similar conclusions reached by other government groups, NSF solicited proposals from institutions with supercomputers to make available their unscheduled computer resources during fiscal 1984. NSF plans to award funding to one or more institutions to make available supercomputer resources to NSF-supported researchers.

NSF is now accepting requests from researchers for computer time. Proposals should be organized according to "Grants for Scientific and Engineering Research" (NSF 83–57). Requests for computer time should be stated in equivalent CPU hours on a particular Class VI machine. To aid in the evaluation of requests, NSF asks that those submitting proposals describe prior experience with Class VI machines and to explain why access to such machines is essential for the successful completion of research. A letter describing these requirements has been sent to all active NSF awardees by Edward F. Hayes, chairman of the NSF Supercomputer Task Force. For additional information, contact the NSF program officer most appropriate to your research field.—*BTR*

## Boninites and Island Arcs

The petrographic term to describe glassy volcanic rocks from the Bonin Islands in the Western Pacific has been around for nearly a century. Currently, however, "boninitic" has come to mean a process, and indeed boninites include in broad set of komatiite-like rocks, which characterize Pacific island arcs. Boninites are usually associated with ophiolites. Their interest geophysically, stems from their probable role in island-arc formation. A while ago W. E. Cameron, E. G. Nisbet, and V. J. Dietrich drew analogies between boninites and Archaean basaltic komatiites and also the well-known variable experimental parameter "pyrolite" (*Nature, 280*, 550, 1979).

More recently, Cameron in collaboration with his Australian National University colleagues M. T. McCulloch and D. A. Walther has alluded to "boninitic volcanism" as a broad phenomenon (*Earth and Planetary Science Letters, 65*, 75–89, 1983). In an analysis of major and minor chemical elements, HREE and LREE, and Nd-Sr isotopic compositions, they observe a chemical decoupling, which suggests that a mixing process was involved with the formation of boninites.

In their recent paper, Cameron and his colleagues state that boninite is the field term for "high MgO, intermediate-$SiO_2$ rock which are unusually primitive ($Mg/(Mg + Fe^{2+}) > 0.7$, high Ni and Cr) and are unique mineralogically: sometimes containing clinoenstatite and, as extrusives, not crystallizing plagioclase." Boninites thus contain quench pyroxene, olivine, or low-Ca pyroxene in glass, which is 30–50% by volume of the rock. In a sense comparable to the adding or subtracting of components in the laboratory to make "pyrolite" come out right, Cameron and colleagues suggest, boninites have had a compound geologic history.

A two-component mixing model is supported by the analyses of boninites from the Bonin Islands, Cape Vagal peninsula, Papua New Guinea, New Caledonia, New Zealand, and Cyprus. The two components include an incompatible, element-depleted lherzolite type of rock and a hydrous, incompatible, element-enriched fluid melt phase. The enriched component fluids could have been derived from many sources. Cameron and colleagues prefer the following: "The presence of two components in boninite genesis may be linked to the common juxtaposition of subducted crust and depleted mantle in subduction zones, allowing ample opportunity for these sources to interact."—*PMB*

## Geophysical Events

This is a summary of *SEAN Bulletin, 8*(10), October 31, 1983, a publication of the Smithsonian Institution's Scientific Event Alert Network. The entire Veniaminof, Villarica, and Tangkuban Parahu reports are included; the Costa Rica and Una Una reports are excerpts. The complete bulletin is available in the microfiche edition of *Eos* as a microfiche supplement or as a paper reprint. For the microfiche, order document E83–011 at $2.50 (U.S.) from AGU Fulfillment, 2000 Florida Avenue, N.W., Washington, DC 20009. For the paper reprint, order *SEAN Bulletin* (giving volume and issue numbers and issue date) through AGU Separates at the above address; the price is $3.50 for one copy of each issue number for those who do not have a deposit account, $2 for those who do; additional copies of each issue number are $1. Subscriptions to *SEAN Bulletin* are available from AGU Fulfillment at the above address; the price is $18 for 12 monthly issues mailed to a U.S. address, $28 if mailed elsewhere, and must be prepaid.

**Correction:** The November 15 issue of *Eos* listed an incorrect document number for ordering *SEAN Bulletin, 8*(9), September 30, 1983. The correct number is E83–010.

### Volcanic Events

Miyakejima (Japan): 4 lava flows, 4 explosion craters from 10-hour eruption
Kusatsu-Shirane (Japan): Explosions eject large tephra
Kilauea (Hawaii): 10th and 11th major phases of E Rift Zone eruption
Mt. St. Helens (Washington): Deformation, $SO_2$ emission, and seismicity increase as lava extrusion pattern changes
Veniaminof (Alaska): Lava fountains and flow; ash emission; increased tremor
Pavlof (Alaska): Large eruption column; tremor
Villarica (Chile): Tephra ejection; pyroclastic flows; summit glow
Costa Rica: Continued lava extrusion at Arenal; fumarolic activity at Poás, Irazú, and Turrialba
El Chichón (México): Fumarole and crater lake temperatures decline
Tangkuban Parahu (Indonesia): Seismicity continues to increase
Una Una (Indonesia): July-August explosion times, plume heights, and photos
Rabaul (New Britain): More than 5000 caldera earthquakes in October, 2.5 x September total and 35 x monthly average; tilt accumulated gradually until stepwise changes of up to 40 microradians accompanied late October swarm
Manam (Bismarck Sea): Tephra clouds; glow; rumbling; increased seismicity
Langila (New Britain): Moderate vulcanian activity; explosion events; tremor
Pagan (Mariana Is.): Explosive eruption on September 26
Atmospheric Effects: Lower stratospheric layer; source uncertain

*Veniaminof Volcano, Alaska Peninsula, USA (56.17°N, 159.38°W). All times are local (= UT—9 hours).* After resuming in early October, eruptive activity continued through early





TABLE 1. Average and Maximum Number of B-Type Events per Day at Tankguban Parahu, Between May and Mid-October 1983

| | May–July | August 1st Week | August Last Week | September 1st Half | September 2nd Half | October First Half |
|---|---|---|---|---|---|---|
| Average | 3 | 10 | 14 | 70 | 57 | 72 |
| Maximum | 7 | 19 | 25 | 120 | 103 | 127 |

TABLE 2. Data on July–August 1983 Explosions of Una Una Volcano, From Volcanological Survey of Indonesia

| Date | Time | Plume Height, km |
|---|---|---|
| July 23 | 1623 | 10 |
| July 25 | 2325–0021 | 7.5 |
| July 27 | 0400–0605 | 7.5 |
| | 1500–2010 | 7 |
| July 28 | 0002–0045 | 8 |
| | 1630–1730 | 8 |
| July 30 | 1615–? | 6 |
| August 1 | 1834–2000 | 7 |
| August 1–2 | 2130–0230 | 6 |
| August 2 | 0314–0600 | 8 |
| | 0800–0900 | 8 |
| August 2–3 | 1905–0200 | 5 |
| August 4 | 0915–1100 | 6 |
| August 6 | 1520–? | 6 |
| August 7 | 1100–1900 | 10 |
| August 11 | 1115–1135 | 8 |
| August 12 | 0047–0147 | 9 |
| August 18 | 1013–1240 | 12 |
| August 22 | 1203–? | 8 |
| August 24 | 2148–2220 | 4 |
| August 25 | 1847–2000 | 5.5 |
| August 26 | 1023–1139 | 10 |

November. On the night of October 23–24, residents of Perryville (population 100, about 25 km S of the volcano) observed lava fountains at the summit, and on October 30 they observed lava flowing down the SW flank of the intra-caldera cone. On October 31 and November 1, an ash cloud rose 1 km above the vent.

Bad weather prevented overflights by USGS personnel during late October. During an overflight on November 4, a very light-colored vapor plume containing a little ash rose approximately 100 m above the vent and then was blown to the S. Lava flowed down the SW side of the intra-caldera cone extending the lava delta to the S. They did not observe any melt water in the large ice pits previously melted into the caldera ice by the lava flows, but the view was obscured by the eruption cloud.

Seismic records available through October 8 showed low-amplitude continuous volcanic tremor beginning October 1 at 1200. On October 2 the amplitude increased to slightly less than half that during the June eruption (see *Eos*, July 5, 1983, p. 441). The tremor remained continuous and of about this amplitude through October 8. Some slightly larger bursts of tremor were recorded October 4–8. The eruptive activity reported on October 3 by the residents of Perryville was not distinguishable on the seismic record.

Information Contacts: Betsy Yount, USGS, 4200 University Dr., Anchorage, AK 99508 USA; Stephen McNutt, Lamont-Doherty Geological Observatory, Palisades, NY 10964 USA.

*Villarica Volcano, S Chile (39.42°S, 71.95°W).* The following is a report from Hugo Moreno Roa.

"Forest Guards in the Villarica National Park reported that the volcano entered into a remarkable eruptive stage on October 14, after a long period of moderate activity. Continuous explosions with tephra emissions and some black pyroclastic flows over the ice-covered slopes have been observed. By night, a red glow over the summit indicates that a lava fountain is filling the crater.

"Villarica last erupted during September 1980 with small explosions and tephra emissions. Since the big lava and pyroclastic eruptions of October–December 1971, active fumaroles have been present in the main crater."

Information Contact: Hugo Moreno Roa, Departamento de Geología y Geofísica, División de Geología, Universidad de Chile, Casilla 13518, Correo 21, Santiago, Chile.

*Arenal Volcano, Costa Rica (10.47°N, 84.73°W).* Lava extrusion has been nearly continuous since 1968 from the active vent at 1450 m altitude at the W end of the elliptical summit crater area. The lava flow that was advancing rapidly down the NW flank in April stopped in July with its front at an altitude of 625 m above sea level. A new flow, the 42nd since 1968, began to emerge in July and by September had reached 1380 m altitude. Gas emission was continuous and strong rumblings were heard.

Information Contacts: Jorge Barquero and Erick Fernández, Programa de Investigaciones Vulcanológicas, Universidad Nacional, Heredia, Costa Rica.

*Tangkuban Parahu Volcano, Java, Indonesia (6.77°S, 107.60°E).* Seismicity began to increase in early June and continued to build through mid-October but no surface changes have been noted. Tectonic earthquakes and both A- and B-type microtremors were recorded. A-type events occurred irregularly, usually at one to three per day, but as many as five were detected on several days. B-type earthquakes increased substantially, as shown in Table 1.

Ground deformation did not show regular changes. From 10 to 25 mm of irregular inflation and deflation were detected but their significance is doubtful. Fumarole temperatures remained stable at 96°C in the three fumarole fields (Baru, Ratu, and Upas). Civil authorities warned of the volcanic hazard and the National Park issued an alert to tourists. Within a 3-km danger zone, camping and auto parking were forbidden.

Tangkuban Parahu's most recent reported eruption was in 1969, when phreatic activity produced a thin ash layer on all sides of the volcano. Increased thermal activity in 1971 ejected small columns of mud.

Information Contact: Adjat Sudradjat, Director, Volcanological Survey of Indonesia, Diponegoro 57, Bandung, Indonesia.

*Una Una Volcano, Sulawesi, Indonesia (0.17°S, 121.61°E). All times are local (= UT + 8 hours).* After at least 10 days of seismicity, a major explosive eruption of Una Una began July 18. All residents of the island were evacuated before the devastating explosions of July 23 (see *Eos*, September 6, 1983, p. 537). A Volcanological Survey of Indonesia team monitored the eruption from near the island. Adjat Sudradjat provided Table 2 of their observations of explosion times and cloud heights, starting with the July 23 activity. Images and a table of data (beginning July 23) from the Japanese GMS geostationary weather satellite are shown in the September 30 *SEAN Bulletin*.

Information Contact: Adjat Sudradjat, Director, Volcanological Survey of Indonesia, Diponegoro 57, Bandung, Indonesia.

### Meteoritic Events

Fireballs: Manitoba, Canada; Czechoslovakia, NW Italy, Netherlands (3); Indiana, Iowa, Ohio, Oregon (2), USA.

### Earthquakes

| Date | Time (UT) | Magnitude | Latitude | Longitude | Depth of Focus | Region |
|---|---|---|---|---|---|---|
| October 4 | 1852 | 7.3$M_s$ | 26.58°S | 70.75°W | 31 km | N Chile |
| October 7 | 1019 | 5.2$m_b$ | 43.94°N | 74.26°W | 13 km | New York, NE USA |
| October 15 | 1057 | 6.7$M_s$ | 8.14°S | 156.36°E | shallow | Solomon Is |
| October 22 | 0422 | 7.0$M_s$ | 60.29°S | 25.84°W | shallow | S Sandwich Is |
| October 28 | 1406 | 6.9$M_s$ | 44.04°N | 113.96°W | 5 km | Idaho, NW USA |
| October 30 | 0412 | 7.1$M_s$ | 40.18°N | 42.29°E | shallow | E Turkey |

# Books

## The Origins of Magnetospheric Physics

James A. Van Allen, Smithsonian Institution Press, Washington, D.C., 1983, 143 pp., $19.95.

*Reviewed by Wilmot N. Hess*

Professor James Van Allen has written a delightful little book on the history of research on the earth's radiation belt. This history is surely unique. It started in the 1950's with a completely new and unexpected discovery about the nature of energetic particles in near-earth space. Three decades later it is a mature science with a general understanding of the distribution and energy of particles near the earth and a reasonably good theory explaining the origins, life histories, and losses.

One man dominated the entire discovery period—James Van Allen. He and several students and young staff members at the State University of Iowa planned the experiments, built the equipment, and analyzed the data from the first four earth satellites that brought back useful data about particles in near-earth space.

In 1958, the radiation-belt era opened explosively, with the launches of Explorer I, Explorer III, Explorer IV, and Sputnik II, all carrying particle detectors, within an 8-month period. But there were carefully laid plans that led up to this explosion. Starting with the V-2 Upper Atmosphere Panel in 1946, a group of U.S. scientists had been planning experiments to study particles in space, using V-2 rockets brought over from Germany and later the U.S. two-stage rocket, Aerobee. By 1955, the International Geophysical Year was being planned and a technical panel on the earth satellite program was set up with Van as a member. This group reviewed proposals and assigned flight priorities for the first set of experiments to be carried out on satellites during the IGY. One of the first four experiments assigned flight priority was "a proposal for cosmic ray observations in earth satellites" by Van Allen.

Though the launching of Sputnik I by the Soviets in October 1957 caused a sensation among the public, U.S. scientists had known that the Soviets were planning to launch satellites during the IGY. Van was on shipboard for a rockoon launching expedition when he heard the news. The excerpts from his log book show how excited he was by this event. The young radio man on the ship told Van, "I think I have it," and signals from the satellite were detected. In his notes Van does some quick calculations to arrive at an estimate of the weight of the Soviet satellite of 100 tons or more. His notes also show how upset he was at the U.S. bureaucracy for not pushing forward with the U.S. program faster. The U.S. had decided that the new Vanguard rocket should be developed even though a team under Werner von Braun, brought over from Peenemunde, Germany, had a Redstone rocket in an advanced state of development and nearly ready to go.

In the scramble after Sputnik I, von Braun promised President Eisenhower that the first Jupiter C with scientific payload would be ready within 90 days. Van's team, with George Ludwig responsible for developing the equipment, prepared a payload that included a Geiger counter; it was launched on Explorer I in January 1958. In March 1958, Explorer III carried a Geiger counter and a tape recorder for a complete orbit.

At about this same time, Van got drawn into the AEC Argus project. Nick Christofolis, a Greek scientist working at the Livermore Laboratory, had proposed that an artificial radiation belt could be constructed in space by the explosion of high altitude nuclear bombs. The Explorer IV satellite, with four instruments from Van's lab, was launched in July 1958. These instruments studied the particle injection from the three Argus explosions and showed that Christofolis' idea, that one could make an artificial radiation belt, was indeed correct.

"Within a fourteen-month period we provided the principal scientific instrumentation for Explorers I, II, III, IV, and V and for Pioneers I, II, III, and IV. Of these nine missions, seven yielded valuable radiation data," Van Allen recounts. It took the data from Explorer III to convince the Iowa team that their instrument was performing properly. They could then see the transitions in radiation counts: first the expected cosmic ray counting rate, then a very high count rate, and then suddenly no counts at all. The process was later reversed, the high counts reappearing suddenly and then decreasing to expected cosmic ray levels. They soon figured out that when the counts came too fast, the system could not accept them and registered zero. The conclusion that indeed there was a very fast count rate due to some unknown particles in space led Ernie Ray to make the famous and facetious remark, "My God, space is radioactive!"

In a relatively short period of time, Van had "concluded that the effect had to be attributed to electrically charged particles constrained by the earth's external magnetic field from reaching lower altitudes and that these particles were in trapped orbits in the geomagnetic field moving in spiral paths back and forth between the northern and southern hemispheres and drifting slowly around the earth."

Van gave a lecture on May 1, 1958, at the National Academy of Sciences in Washington, laying out these discoveries of the radiation encircling the earth. A reporter asked, "You mean like a belt?" Van replied, "Yes, like a belt," and evermore it has been the Van Allen radiation belt.

This little book (it is 120 pages plus several appendices) is an important contribution to the history of science and a delightful re-visit to those early days when this field was new and exciting and Van was personally contributing the majority of the new information on the subject. It was exciting to read sections of his log book and his personal comments about the confusion, opportunities, and gains of those early days. Van sums it up by saying, "I consider 1958 the most intense and rewarding year of my professional life. We had a minimal burden of paper work and enjoyed extraordinary free and entrepreneurial working circumstances. It is scarcely necessary to remark on the contrast with the 1983 circumstances of conducting space research which require massive proposing, defending, documenting, re-proposing, reporting, financial and activity accounting and typically a time lapse of a decade between the start of a project and its consummation."

Van's first experiment cost $167,000; now, with R and QA and parts traceability and documentation, it would cost several million. The good old days clearly are gone for this subject but they were exciting. It is extremely valuable to have the man who played the central role re-create them for us.

*Wilmot N. Hess is with the National Center for Atmospheric Research, Boulder, CO 80307.*



## Geodetic Applications of Radio Interferometry

Proceedings of Symposium No. 5, IAG Tokyo, *NOAA Tech. Rep. NOS 95 NGS 24*, National Geodetic Information Branch, NOS/NOAA, Rockville, Md., xii + 334 pp., 1983, $12.

*Reviewed by C. Boucher*

These proceedings contain the papers presented during Symposium No. 5, *Geodetic Applications of Radio Interferometry*, of the International Association of Geodesy General Meeting held in Tokyo, May 7–8, 1982. The symposium, organized by the IAG Special Study Group 2.51 on Radio Interferometry, had eight sessions and 36 papers. Radio interferometry on satellites, such as GPS, was not included because this topic had been extensively discussed during other IAG meetings, such as the Third International Symposium on Satellite Doppler Positioning held in Las Cruces, N. Mex., in February 1982.

The first session contained six papers on reference frames. K. I. Kellermann's contribution illustrated source structures and their frequency and time variations, which have significant influence for the maintenance of a

Books *(cont. on p. 966)*

## Books (cont. from p. 965)

celestial radio catalogue at the milliarcsecond level and for the simultaneous use of two frequencies during Very Long Baseline Interferometry (VLBI) sessions. The second paper, by K. J. Johnston and J. S. Ulvestad, was devoted too to celestial frame by comparing several radiosource catalogues. Some useful recommendations are made for future works, particularly by proposing a set of about 40 sources to be observed by all investigators.

Two papers were related to the definition and maintenance of a conventional terrestrial system by space techniques, especially VLBI. S. Manabe's contribution was devoted to some numerical computations using several possible networks. In case of a VLBI network, simulations have shown that 80% of the actual station displacements were recovered for an eight-element network. The paper is not self-explanatory. The reader should first consult Y. Bock and Shen Ivan Zhu's paper, which is a clear, general presentation of the problems (relations between inertial and terrestrial frames, combination of various techniques such as VLBI, SLR, and LLR, maintenance of a terrestrial frame for a deformable earth, choice of the estimation).

The paper by M. K. Fujimoto et al. dealt with relativistic modeling of reference frames. Relations between solar system barycentric, geocentric, and topocentric frames were discussed but formulas for the relation between only the first two are presented. Although very dense for a nonspecialist, this presentation is rather comprehensive and I recommend it.

Five papers belong to session 2 on earth rotation. The first one, by D. D. McCarthy et al., dealt with results of connected element interferometry. Present results are derived from only one baseline. They show an internal precision of 0.2–0.8 ms and an accuracy of 0.5–1.0 ms. As such results can be obtained only a few days after the observation time, they are particularly suitable for a rapid service. A second baseline and a better modeling of refraction will improve these results. Other papers covered the NGS Polaris system; the results of a global analysis of 10 years of VLBI data collected by the Deep Space Network; the Jet Propulsion Laboratory (JPL) TEMPO program for a rapid and operational determination of earth rotation parameters; and a pioneering VLBI experiment.

Three papers from session 3, on radiointerferometric surveying, are included in the proceedings. The first one, by G. Lundquist, reported VLBI determination of a 600-m baseline between two radiotelescopes at Onsala, Sweden. Two experiments using a Mark III system show a sub-centimeter repeatability, and an agreement with a conventional survey better than 4 cm. A closure experiment with various trans-Atlantic baselines, Haystack–Onsala, performed between 1972 and 1978 shows a good agreement in length (2 cm) but a drastically worse agreement in orientation (up to 1 m in the Z component). More extensive comments on this last result would have been helpful.

A second paper, by W. Beyer et al., described the European Radiointerferometry and Doppler Campaign (ERIDOC). Several bandwidth synthetic Mark II experiments provided baselines between six European radiotelescopes with a repeatability better than 30 cm. Comparison with Doppler-derived baselines, using colocated receivers and DMA precise ephemerides, shows generally good agreement if one removes a scale and rotation bias. Nevertheless, the values of these parameters do not fully agree with those found by L. Hothem et al. in 1982. Further investigations about intercomparisons, especially on a full error budget, including local connections, are needed.

The last paper, by D. W. Trask et al., was devoted to results of the National Aeronautics and Space Administration/JPL mobile VLBI stations, used to survey some 17 sites in California from 1974.

Session 4 contained six papers devoted to VLBI systems. The first three covered the Mark III system; the next two described the Japanese K-3 system, fully compatible with Mark III; and the last presented the JPL/CIT correlator named Block II, which is also compatible with the Mark III system.

Session 5 provided five contributions on atmospheric and ionospheric propagation effects; session six, four papers on new instrumentation and techniques; and session seven contained five papers devoted to future plans.

This report will provide a good review of the state of the art of radiointerferometric techniques as applied to geodesy.

*C. Boucher is with the Institut Géographique National, 94160 Saint-Mandé, France.*



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POSITIONS AVAILABLE

**Colorado School of Mines/Research Fellowship.** Research Fellowship in the isotopic geochemistry of extraterrestrial rocks. The study concentrates on nuclear geochemistry and geochronology of Lu-Hf, Sm-Nd, Rb-Sr, and U-Th-Pb systems in meteorites, lunar samples, and relevant terrestrial systems. This is a joint research program with the Colorado School of Mines and the U.S. Geological Survey. The appointee will perform most of the experiments at the USGS Isotope Branch, where up to date facilities are available for isotopic studies. Candidates should have a Ph.D. in geochemistry or planetary sciences. Experience in mass spectrometry or radio chemistry is desirable. The stipend is $21,000-$25,500 per year depending on experience and tax status. Begins on February 2, 1984 for 1, possibly 2 years. Send resume, two letters of recommendation, and a statement of research interests to: Thomas R. Wildeman, Dept of Chemistry/Geochemistry, Colorado School of Mines, Golden, Colorado 80401. Phone: (303) 273-3000.

CSM is an equal opportunity/affirmative action employer.

**Hamilton College/Faculty Position.** Applications are invited for a tenure-track position starting September 1984 at the Assistant Professor level. This position will expand the department from three to four faculty members. We seek a person with a PhD who is strongly oriented toward undergraduate teaching and whose field of training and interest are in any of the following fields: geophysics, low-temperature geochemistry, oceanography. Highly qualified candidates in other areas will also be considered. The successful candidate will be expected to contribute to introductory courses offered by the department, teach advanced undergraduate courses, and maintain a research program.

Hamilton is a private, coeducational liberal arts college with 1600 students. The department has an active program with 10–15 majors in each class, excellent facilities and equipment, and a strong emphasis on field work.

Candidates should send letters of application, resumes, transcripts, and three letters of recommendation to: Donald B. Potter, Chairman, Department of Geology, Hamilton College, Clinton, NY 13323.

Hamilton College is an equal opportunity employer. Women and minorities are encouraged to apply.

**Sedimentary Biogeochemist/University of Hawaii.** The Department of Oceanography and Hawaii Institute of Geophysics, University of Hawaii, are searching for a creative marine scientist for a tenure track position at the Assistant or Associate Professor level, with interest in seawater-mineral interactions. Applicants should have talents for investigation of problems involving both organic and inorganic phases.

The Department and Institute have a wide range of facilities available including research vessels and fully-equipped environmental chemistry, low-temperature geochemistry, and sedimentology laboratories, as well as XRD, XRF, SEM, STEM, GC, LC, IR, Raman, microprobe, mass spectrometry and radiochemical instrumentation.

The scientist selected will be expected to develop a research and teaching program and to guide and support graduate students. Applications and names of three referees should be sent to Dr. Keith E. Chave, Department of Oceanography, 1000 Pope Road, University of Hawaii, Honolulu, HI. 96822. Closing date 1 January 1984 for starting date 1 August 1984.

The University of Hawaii is an Equal Opportunity/Affirmative Action Employer.

**University of Iowa/Faculty Positions.** The Department of Physics and Astronomy anticipates two openings for tenure-track assistant professors or visiting faculty at any level in August 1984. In exceptional cases a term or tenured appointment at the associate professor or professor level will be considered. Preference for one position will be given to an experimentalist in intermediate or high energy physics. Current research interests in the department are radio and optical astronomy and the following specialties in physics: atomic, condensed matter, elementary particle, laser, nuclear, plasma, and space physics. Faculty duties include undergraduate and graduate teaching, guidance of research students and personal research. Interested persons should submit a resume and a statement of research interests and arrange for three letters of recommendation to be sent to Search Committee, Department of Physics and Astronomy, The University of Iowa, Iowa City, IA 52242.

The University of Iowa is an equal opportunity/affirmative action employer.

**Ohio State University/Mineralogist.** The Department of Geology and Mineralogy invites applications for a tenure track position in mineralogy or mineralogy/petrology (this is a position that has been reopened). The successful applicant will be expected to interact with other members of the faculty in the fields of mineralogy, petrology, geochemistry, and economic geology.

A Ph.D. or equivalent is required. The successful applicant will be expected to teach graduate and undergraduate courses, conduct research, and supervise graduate students. Rank and salary will be commensurate with experience and research record. Please send applications to:

Dr. David H. Elliot
Chairman, Search Committee
Department of Geology and Mineralogy
The Ohio State University
Columbus, OH 43210

Applications should include resume, statement of research record and interests, and the names of at least three persons who can provide recommendation. The closing date for applications is December 31, 1983; the appointment will be effective no later than October 1, 1984. Additional information can be obtained by writing or calling (614) 422-6531.

The Ohio State University is an equal opportunity/affirmative action employer.

**National Center for Atmospheric Research/Ph.D. Researcher.** NCAR's Atmospheric Chemistry and Aeronomy Division seeks experienced Ph.D. researcher with record of sustained productivity in theory and modeling of atmospheric chemistry. Primary interest is in gaseous photochemistry and coupled chemical/meteorological models, but all specialties will be considered along with scientific breadth. Appointment is at Scientist III or Senior Scientist level. Apply with resume to Dr. R. Cicerone, National Center for Atmospheric Research, P.O. Box 3000, Boulder, Colorado 80307, by December 20, 1983.

Equal Opportunity Employer M/F.

**University of California, San Diego/Assistant Research Chemist.** The Institute of Marine Resources at the Scripps Institution of Oceanography, University of California San Diego, anticipates an opening for an ASSISTANT RESEARCH CHEMIST (salary range: $22,900-$26,800) in the Food Chain Research Group. The primary responsibility of the position is to carry out fundamental research in marine organic chemistry in association with others of IMR oceanographers.

Applicants must have (i) a Ph.D. in organic chemistry, marine chemistry or chemical oceanography and at least two years of post-doctoral experience in marine chemistry; (ii) an ability to carry out independent research in the ocean as demonstrated by an active publication record in refereed journals; and (iii) experience in work at sea with modern sampling and analytical methods.

Send resume and names of three referees by March 1, 1984, to:

Dr. Fred N. Spiess, Director
Institute of Marine Resources, A-028
Scripps Institution of Oceanography
University of California San Diego
La Jolla, California 92093

The University of California San Diego is an equal opportunity/affirmative action employer.

**Geophysicist or Tectonophysicist/University of Kansas.** KU seeks applications for a tenure-track faculty position in geophysics. Candidates should have research interests in crustal geophysics. The successful applicant will be expected to teach undergraduate and graduate geophysics courses, develop an active research program, advise students, supervise graduate student theses and dissertations, and provide service through administrative and professional activities. A Ph.D. in geology with specialization in geophysics is required although applicants who will complete the Ph.D. within the first year of employment at KU will be considered. The position is at the assistant professor level with a salary commensurate with qualifications. The starting date is ugust 16, 1984 and the application deadline is February 1, 1984. Send vita, transcripts, a brief statement of research interests and courses the applicant feels qualified to teach, and three letters of reference to G. H. Girty, Department of Geology, University of Kansas, Lawrence, Kansas 66045. The advertised position is contingent on continued state funding. For additional information contact G. H. Girty or phone (913) 864-4974.

KU is an affirmative-action, equal-opportunity employer. Applications are sought from all qualified people regardless of race, religion, color, sex, disability, veteran status, national origin, age, or ancestry.

**Hydrogeologist/University of Illinois at Urbana-Champaign.** The Department of Geology has reinstituted its search for a hydrogeologist to fill a permanent, tenure-track faculty position. The appointment will be at the Assistant Professor level. Salary is negotiable. A Ph.D. is required. Starting date will be August 21, 1984. The successful candidate will have a demonstrated background in one or more of the following areas of hydrogeology: basin analysis, flow in porous media, or chemical interactions between groundwater and rock and will be expected to teach one or more graduate courses in hydrogeology, to participate in our undergraduate instructional program, and to maintain and enhance our existing strong research program in hydrogeology. For equal consideration, application including the names of three referees should be sent by February 1, 1984 to:

Professor R. James Kirkpatrick
Department of Geology
245 Natural History Building
1301 West Green Street
Urbana, IL 61801
Ph: (217) 333-3542

The University of Illinois is an Affirmative Action/Equal Opportunity Employer.

## PHYSICIST/UNDERWATER ACOUSTICIAN

**The Office of Naval Research** is seeking a highly qualified physicist or underwater acoustician to serve as Group Leader to plan and manage a contract research and development program. The research sponsored is conducted principally at universities and industrial laboratories by leading scientists in the field. This is a Civil Service position at the GM-14 ($41,277–$53,661) or GM-15 ($48,553–$63,115) level, depending on individual qualifications.

**The incumbent is responsible** for planning, coordinating and directing a basic and applied research program in underwater acoustics related to ocean science, engineering and technology; undersea surveillance; anti-submarine warfare; prosubmarine warfare; and undersea acoustic weapon systems. Responsibility includes analysis of research proposals, recommending appropriate action, following the programs of funded contracts in thorough technical detail, determining when contracts and programs should be terminated, insuring timely and effective dissemination of research results to other Naval elements having a need for those results, and insuring that the program content meets anticipated Navy needs. Incumbent will be required to describe and justify his/her programs both in writing and orally within the organization and to responsible bodies in the Navy and DoD.

**Applicants must have a Ph.D. degree** or equivalent in physics or a related physical science and a minimum of three years of progressively responsible professional experience. At least one year of experience must be comparable in difficulty and responsibility to the next lower level in the Federal Service. Demonstrated research experience is preferred. Equivalent combinations of professional experience and graduate education may be acceptable.

**Interested persons** should submit a resume or Standard Form 171, Personal Qualifications Statement (available at Federal Job Information Centers or from the address below), to:

**OFFICE OF NAVAL RESEARCH** Civilian Personnel Division, Code 791SC
**ATTN.: Announcement #83-56 (EOS)** • 800 North Quincy Street • Arlington, VA 22217

Applications will be accepted through 31 January 1984 and must be received by that date. For further information and supplemental forms, please call (202) 696-4705.

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**University of Texas at Austin/Getty Chair.** The Department of Geological Sciences seeks a person at the rank of full professor to occupy the recently endowed Getty Chair effective September 1, 1984. Teaching obligations include one undergraduate or graduate course each semester and the supervision of graduate students in the areas of the person's interest. A willingness to teach courses for non-majors on occasion is desirable. The person's field of research must be one that is related in a broad sense to the exploration for hydrocarbons. The Getty endowment will provide the chair holder with modest funds for support of travel and research activities. Applicants should submit a detailed resume, names and addresses of five references, and a statement of teaching and research interests by February 1, 1984 to: Dr. Earle F. McBride, Chairman, Department of Geological Sciences, P.O. Box 7909, Austin, Texas 78713-7909.

The University of Texas at Austin is an Equal Opportunity/Affirmative Action Employer.

**The College of William and Mary/Physics Faculty Position.** William and Mary expects to have a tenure-track opening at the assistant-professor level for August, 1984. Preference will be given to applicants in the fields of theoretical plasma physics (including computer simulation), nonlinear mechanics, or statistical mechanics. The physics department currently consists of 22 faculty, 7 postdoctoral research associates, and 40 Ph.D. candidate graduate students. Plasma physics funding is currently from NASA and the Department of Energy. Please send vitae and list of three references to: Chairman, Search Committee, Physics Department, College of William and Mary, Williamsburg, Virginia 23185.

William and Mary is an affirmative-action, equal-opportunity employer; women and minority applicants are encouraged to apply.

**The University of New Mexico/Mass Spectrometry.** The Department of Geology, University of New Mexico, Albuquerque is seeking applicants for a research associate position in the stable isotope laboratory. The position includes responsibility for operation and maintenance of mass spectrometers and high vacuum extraction systems, sample preparation and isotopic analyses. The position also provides opportunities for collaborative research in isotope geochemistry leading to publication. A Ph.D. in geochemistry, inorganic chemistry, or physical chemistry with research experience involving mass spectrometry and high vacuum technology is required. Send a letter of application, resume, and the names and addresses of three individuals willing to serve as references to: Crayton J. Yapp, Department of Geology, University of New Mexico, Albuquerque, NM 87131. Closing date for applications is February 1, 1984. The availability of this position is contingent on final budget approval.

The University of New Mexico is an equal opportunity employer.

**University of Massachusetts, Amherst/Faculty Position in Stratigraphy-Micropaleontology.** The Department of Geology and Geography invites applications for a tenure-track position at the assistant professor level in stratigraphy/micropaleontology. Research and supervision of graduate students concentrating in those fields will be expected. Additional research interests in paleo-oceanography or petroleum geology are desirable. The successful candidate will be expected to teach a one-semester course in stratigraphy every year, a one-semester course in introductory oceanography every other year and to develop additional courses in his/her area of expertise. Application including a resume, a statement of teaching and research interests, and the names and addresses of at least three referees should be sent no later than February 15, 1984 to: Dr. Charles W. Pitrat, Chairman, Search Committee, Dept. of Geology and Geography, University of Massachusetts, Amherst, MA 01003

The University of Massachusetts is an Affirmative Action/Equal Opportunity Employer.

**Hydrologic Modeler/University of Wisconsin-Milwaukee.** The Department of Geological and Geophysical Sciences at the University of Wisconsin-Milwaukee invites applications for a probable tenure-track position of Assistant Professor beginning in Fall, 1983, to join a broad program in hydrospheric, geological, atmospheric and geophysical sciences. Applicants' primary strength should be in the application of numerical models to ground water flow and chemical transport systems. A strong chemical background or modeling experience with flow in fractured media or contaminant migration would be helpful. Further, ability to apply modeling techniques to problems in other aspects of the geosciences will be important.

The successful candidate will be expected to teach an applied senior level course in the theory and application of finite element, finite difference methods to problems of hydrology and geophysics. The candidate is expected to develop additional graduate level courses in hydrology and to teach general geology at the undergraduate level. Ability to teach geophysical fluid dynamics would be valuable.

Research programs at UWM include lake infiltration into aquifers, use of aquifers for compressed-air storage, Great Lakes contamination and sediment processes, the use of applied geophysics in determining hydraulic properties and flow, and severe-storm modeling. Facilities include a Great Lakes Research Center with research vessels and pier facilities, an Urban Research Center and a rural field station.

Candidates should forward resumes, complete transcripts and three letters of recommendation to Professor D. S. Cherkauer, Chair, Department of Geological and Geophysical Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI 53201. Salary range has not yet been formally approved, but will probably be in the $23,000—$25,000 range. Closing date for applications is January 31, 1984.

UWM is an affirmative-action, equal opportunity employer.



**Postdoctoral Research Position/University of California, Berkeley.** A postdoctoral research position in petrophysics is available immediately in the Department of Mechanical Engineering. The Department has recently installed in the Petroleum Engineering Laboratory a nuclear magnetic resonance facility, having a large magnet gap. The successful candidate must be knowledgeable and experienced in NMR techniques, and will be expected to employ this and other petrophysics research techniques in an interdisciplinary approach to a program directed at the petrophysics of porous sedimentary rocks, and the physical properties of permafrost. Resources of other University Departments and of the Lawrence Berkeley Laboratory will also be available to the research program.

Send resume and the names of three references to Professor W.H. Somerton, Department of Mechanical Engineering, University of California, Berkeley CA 94720.

The University is an Equal Opportunity/Affirmative Action Employer.

**Geophysicist, Tectonophysicist/Georgia Tech.** The School of Geophysical Sciences at Georgia Tech invites applications for a faculty appointment in Earth Sciences. Applicants must have an outstanding research potential demonstrated by several years of postdoctoral experience or a well-established research record, and experience in securing research funding. Although no field of specialization is excluded, preference will be given to candidates with a background in geophysics/tectonophysics.

The School of Geophysical Sciences has an expanding and active research program in many areas of Earth and Atmospheric Sciences. The School has 23 full-time faculty members and over 50 graduate students.

Applications including resumes, phone numbers, and the names and addresses of at least three references should be submitted to Jean-Claude Mareschal, Chairman, Geophysics Search Committee, School of Geophysical Sciences, Georgia Institute of Technology, Atlanta, GA 30332.

The Georgia Institute of Technology is a unit of the university system of the State of Georgia.

Georgia Tech is an affirmative action/equal opportunity employer.

**University of Washington/Paleontology/Paleobiology, Geochemistry.** The Department of Geological Sciences invites applications in the areas of paleontology/paleobiology and geochemistry (especially economic or isotope geochemistry). We are interested in candidates who will establish exceptional and innovative research programs. Postdoctoral research experience is highly desirable. One opening is available beginning September 1984. This is a tenure-track position at the rank of Assistant Professor or higher under exceptional circumstances. A second position may be available in September 1985. A paleontologist/paleobiologist may seek a joint appointment with the Burke Museum on campus. A successful candidate in either area will be expected to teach at both the undergraduate and graduate levels.

Applicants should send vitae and names of four references to John B. Adams, Chairman, Department of Geological Sciences, AJ-20, University of Washington, Seattle, Washington 98195. Closing date for applications is February 15, 1984.

The University of Washington is an Affirmative Action/Equal Opportunity Employer.

**Climatologist-Postdoctoral Research Scientist/Lamont-Doherty Geological Observatory of Columbia University.** Individual should be interested in climatic variations over the past several centuries. Tree-ring data and climatic reconstructions are available or under development for assembling into areal studies and analyses of climate dynamics. The long-term data is to be used in studying various forcing phenomena and regional variations. Experience in data analysis and knowledge of programing in FORTRAN and BASIC will be extremely useful. Applicant should have a strong commitment to research and anticipate being involved in preparation of papers and proposals.

Send letter of application, resume and names of at least three references by 10 January 1983 to:

Gordon C. Jacoby
Tree-Ring Laboratory
Lamont-Doherty Geological Observatory
Palisades, New York 10964

Position is a one-year appointment with possible second-year renewal.

Columbia University is an affirmative action, equal opportunity employer.

**Mineralogist/Petrologist/Geochemist—South Dakota School of Mines.** A position as Research Scientist I (research equivalent of assistant professor) is currently available in the Institute for the Study of Mineral Deposits (ISMD) at the South Dakota School of Mines and Technology, Rapid City, South Dakota. A Ph.D. degree in the general areas of mineralogy-petrology-geochemistry is required and the Ph.D. degree must be in hand before assuming the position with ISMD. The successful applicant will interact with the several research programs conducted by ISMD with special emphasis on the mineral deposits of the Black Hills, South Dakota. Major research responsibility will concern a long-term, in-depth study of stratiform gold deposits in the Black Hills. ISMD has a fully automated (WDS + EDS) microprobe and a new state of the art automated atomic absorption spectrometer with inductively coupled plasma torch (AA/ICP) for major, minor and trace element analysis. Arrangements are in place for neutron activation analysis (Battelle, Richland, Washington) and light stable isotope analysis (U.S.G.S.).

Candidates for the position should send resumes and three letters of recommendation to:

J.J. Papike, Director, ISMD
South Dakota School of Mines and Technology
500 East St. Joseph Street
Rapid City, South Dakota 57701–3995

For additional information, call (605) 394-6152. SDSM&T is an affirmative-action/equal opportunity employer.

**Texas A&M University/Geological Oceanography Positions.** The Ocean Drilling Project (ODP) invites application for the following anticipated positions: Several full-time staff scientists (Ph.D. required). These openings, in various fields of marine geoscience, are anticipated to be filled over a one year period commencing 1 October 1983. The successful candidates will be expected to participate approximately two months per year aboard a scientific drillship. These individuals will be responsible for coordinating activities prior and subsequent to the cruises, including the publication of results. The successful candidates will be expected to attend the JOIDES panel meetings relating to their scientific expertise. Several full-time marine technicians. Previous shipboard experience and undergraduate degree in geology or related science highly desirable. These positions require participation of about 6 months per year (alternating two months on and two months off) aboard a scientific drillship charter.

Applicants should submit a letter of application, curriculum vitae and names of 3 references to: Dr. Philip D. Rabinowitz, Project Director, ODP, Dept. of Oceanography, Texas A&M University, College Station, TX 77843.

Texas A&M University is an Equal Opportunity Employer.

## CSIRO
## APPLIED MICROMETEOROLOGIST
### $A24,344 — $A30,038
### DIVISION OF ENVIRONMENTAL MECHANICS
### CANBERRA ACT
### AUSTRALIA

CSIRO conducts scientific and technological research in laboratories located throughout Australia and employs about 7,500 staff, of whom some 2,900 are professional scientists. The Organisation's research activities are grouped into five institutes: Animal and Food Sciences, Biological Resources, Energy and Earth Resources, Industrial Technology and Physical Sciences. The CSIRO Divison of Environmental Mechanics is a member of the Institute of Physical Sciences.

Research in the Division of Environmental Mechanics is directed primarily at gaining a better understanding of the biological and physical processes of the soil-plant-atmosphere system with particular regard to the transport of energy, water, nutrients and other materials. Facilities include laboratories for soil physics, solar radiation, fluid mechanics, micrometeorology and plant physiology, as well as mobile laboratories for study of the field environment. The laboratory has a large and well instrumented boundary layer wind tunnel, and computer facilities for the collection and analysis of experimental data. The Division has a micrometeorology field site located 45km from Canberra. Divisional staff at present includes 15 research scientists (biologists, physicists and mathematicians) together with experimental and technical staff, and is usually augmented by several visiting research workers.

The Division's Micrometeorology program investigates the turbulent transfer of heat, momentum, and water vapour in the atmospheric surface layer, and within and above plant canopies, research which involves parallel and complementary work in the field and in the Division's wind tunnel. Special emphasis is given to the effects, on these transfer processes, of complicated surface geometry including barriers, hilly terrain and spatial variability of surface roughness.

Applications are invited for the following position:

**A2857 — Micrometeorologist/Fluid Mechanicist.**

DUTIES: To undertake field, wind tunnel and theoretical studies on aspects of turbulent flow and transport relevant to industry, agriculture and the community, and to assist in the application of the results of this work to practical problems.

Applicants should have a PhD degree or equivalent, supported by evidence of proven research ability in the field of fluid mechanics and/or heat and mass transfer. Experience in the modelling of fluid flows by wind tunnel or other laboratory technique is highly desirable.

A fixed term appointment of three years within the classification of Research Scientist. An applicant with an outstanding research record may be offered appointment at a higher level. Australian Government superannuation benefits are available.

Applications, stating full personal and professional details, the names of at least two scientific referees, and quoting reference No A2857 should be directed to:

**The Chief**
**CSIRO Division of Environmental Mechanics**
**CSIRO**
**GPO Box 821**
**CANBERRA ACT 2601**
**AUSTRALIA**
**By 6 January 1984.**

38629

**University of Wisconsin-Madison/Tenure Track Position.** The Department of Geology and Geophysics invites applications for an anticipated tenure-track position at the assistant-professor level in applied geomorphology and hydrogeology commencing in August 1984. The applicant should be committed to developing a strong research program as well as teaching undergraduate courses in some aspects of engineering and environmental geology. The Ph.D. is required. Applicants with course work in engineering and an interest in the field application of geologic principles are especially encouraged to apply.

Send letter of application outlining your professional goals, transcripts, resume, copies of publications, and three letters of reference to Dr. David M. Mickelson, Department of Geology and Geophysics, Weeks Hall, University of Wisconsin, Madison, WI 53706.

The University of Wisconsin is an equal-opportunity/affirmative-action employer.

**Post-Doctoral Position/Naval Postgraduate School.** The Ocean Turbulence Laboratory has available a post-doctoral position for a person interested in the analysis and interpretation of oceanic turbulence data. The tenure is for 1 or 2 years. The successful candidate should have a Ph.D. in physical oceanography and although experience with turbulence data is preferrable it is not essential. The opportunity for involvement in data gathering expeditions is also available.

Resumes can be sent to Dr. R. G. Lueck, Code 68Ly, Naval Postgraduate School, Monterey, CA 93943.

The Naval Postgraduate School is an Equal Opportunity/Affirmative Action Employer.

**University of California/Faculty Appointments.** The Department of Geology and Geophysics at the University of California, Berkeley, CA. 94720, pending budgetary approval, expects to make two faculty appointments effective Fall 1984, one at the junior level and one at the senior level. Applicants must be interested in pursuing a vigorous research program and in teaching both undergraduate and graduate students. The preferred areas of specialization are sedimentary petrology and sedimentology, stratigraphy and petroleum geology, regional tectonics, geochemistry, economic geology, and metamorphic geology. Applications, including the names of references, should be sent to the Chairman at the above address by January 15, 1984.

The University of California is an Equal Opportunity/Affirmative Action Employer.

**University of Georgia/12-month tenure-track faculty appointment in the School of Forest Resources.** Qualifications: Ph.D in hydrology or forest hydrology with at least one degree in forest resources. Background should include forest resource management and quantitative sciences. Responsibilities: Teach undergraduate and graduate level courses in forest hydrology and watershed management. Develop a research program in an appropriate area of forest hydrology. Rank: Assistant or Associate Professor, commensurate with qualifications. Salary: Commensurate with training and experience. Position available: July, 1984. Applications: All applications must be postmarked no later than 1 February 1984. Submit resume, transcripts, and names of at least three references to:

Klaus Steinbeck, Chairman
Hydrologist Search Committee
School of Forest Resources
University of Georgia
Athens, GA 30602
Telephone 404-542-1376

The University of Georgia is an Equal Opportunity/Affirmative Action Institution.

**SUNY-Albany/Tenure-Track Position in Tectonics or Structural Geology.** The Department of Geological Sciences at the State University of New York at Albany invites applications for a tenure track position in TECTONICS or STRUCTURAL GEOLOGY starting Fall, 1984. We welcome applicants with interests and experience in tectonic processes, including geophysical and structural approaches; structural geology, including physical properties of earth materials or structural aspects of metamorphic processes; or similar fields which complement our existing strengths. Preference will be given to individuals whose research combines quantitative and field studies. The position will be filled at the Associate or Assistant Professor level. Inquiries or applications should be addresed to Dr. W.D. Means, Department of Geological Sciences, State University of New York at Albany, 1400 Washington Avenue, Albany, New York 12222. Application deadline is February 15, 1984.

SUNY-Albany is an equal opportunity/affirmative action employer. Applications from women, minorities, handicapped and Viet Nam era veterans are especially welcome.

**University of Washington/Faculty Position in Geophysics.** The Geophysics Program at the University of Washington invites applications for a tenure-track position. The successful candidate will be expected to teach courses at the senior and graduate student level and to establish innovative, forward-looking research programs. Applicants with a Ph.D. and evidence of outstanding potential in basic research in any subfield of solid-earth geophysics will be considered. However, applicants with prime interest in studying global seismology or in studying the physical properties of the earth's mantle and core will receive preference. Curriculum vitae and four letters of reference should be sent prior to 31 January 1984 to:

Professor Ronald T. Merrill
Chairman, Recruitment Committee
Geophysics Program AK-50
University of Washington
Seattle, Washington
Seattle, WA 98195

The University of Washington is an affirmative action/equal opportunity employer.

**Physical Oceanographer/The Woods Hole Oceanographic Institution.** Plans to make a tenure-track appointment as Assistant Scientist in the Department of Physical Oceanography. Applicants should have a degree in Physical Oceanography or a closely related field and, preferably, some post doctoral experience. A candidate's area of expertise in oceanography is not specified, but a working knowledge of fluid dynamics is an important qualification. Please send vitae to the Chairman, Physical Oceanography Department, Box 54 P, WOODS HOLE OCEANOGRAPHIC INSTITUTION, Woods Hole, MA 02543.

An equal opportunity employer.

**Physical Oceanographer/Oregon State University.** Assistant or Associate Professor, depending on experience. Applicants may be observationalists or theoreticians but must have a Ph.D. in the physical sciences, have demonstrated the ability to conduct independent high-quality research and are expected to obtain research funding. Duties include teaching and supervision of graduate students. Interested candidates should submit a resume and names of three references by 1 February 1984 to: G. Ross Heath, Dean, College of Oceanography, Oregon State University, Corvallis, OR 97331.

OSU is an Affirmative Action/Equal Opportunity employer, complying with Section 504 of the Rehabilitation Act of 1973.

AGU

# Actions at Hamburg

## International Association of Hydrological Sciences

### Symposia

The proceedings of two of the five IAHS symposia at Hamburg were prepublished: *Dissolved Loads of Rivers and Surface Water Quantity/Quality Relationships* and *Hydrology of Humid Tropical Regions with Particular Reference to the Hydrological Effects of Agriculture and Forestry Practice*. These can be purchased from the Office of the Treasurer, 2000 Florida Avenue N.W., Washington DC 20009. The remaining proceedings will be published in 1984.

### Resolutions

Reproduced below are resolutions adopted by IAHS during the 18th General Assembly of the International Union of Geodesy and Geophysics (IUGG) in Hamburg, August 15–27, 1983.

The resolutions passed at each quadrennial general assembly of IUGG and of its member associations are an important barometer of current opinion in the geophysics community and can be a powerful tool in the development of the scientific programs to which they are addressed. The resolutions will help advance programs, however, only if they are used. Carried back home by the national committees which make up the IUGG, the resolutions can spread information worldwide on programs that promise to most effectively advance geophysical knowledge. IUGG and its member associations intend that member groups will present the resolutions before deliberative bodies and otherwise use them to make decision makers aware of international scientific thought.

The 19 resolutions adopted by IUGG as a whole appeared in *Eos*, October 4, 1983, p. 582.

**Resolution 2/1**

Appreciating highly the close cooperation with UNESCO and WMO in the framework of the IHP and the OHP, respectively, recommends that the IAHS commissions take active part in the preparation and implementation of the third phase of IHP, continue their participation in the OHP, and ensure through their activities in the International programs the promotion of both the advancement of hydrological sciences and the transfer and dissemination of existing scientific results; and invites the Bureau of IAHS to strengthen the cooperation of the Association with other UN organizations dealing with water problems, such as FAO, WHO, IAEA, UNEP and the regional UN Economic Commissions.

**Resolution 2/2**

Considering that the future of this Association rests in the active participation of young hydrologists in its affairs, instructs the Bureau to establish from amongst young hydrologists a Working Group in cooperation with UNESCO and WMO to consider and report on the prospects for hydrology in the years leading to the 21st century, and further instructs the Bureau to recognize the scientific contributions of a young hydrologist by making an annual monetary award to be known as the Tison Award on the basis of a paper published in the *Hydrological Sciences Journal* or in the Proceedings of a symposium published by the Association.

The following comments are from Secretary General Rodda:

The Working Group referred to in Resolution 2/2, the so called Hydrology 2000 Working Group, consists of the following members: D. N. Collins (UK), S. I. Haswain (Libya), L. T. Gottschalk (Sweden), Z. Kundzewicz (Poland), A. Szollosi-Nagy (Hungary), E. D. Andrews (USA), B. Webb (UK), and A. Afouda (Peoples Republic of Benin). A small subcommittee was formed to consider the exact terms of the Tison Award. It consists of I. Rodriguez-Iturbe, A. I. Johnson, and T. O'Donnell.

A third resolution was concerned with strengthening the position of hydrologists and IAHS within IUGG. In the past, few of the IUGG officers have been hydrologists, and currently none of the members of the IUGG council, which is composed largely of chairmen of IUGG national committees, is a hydrologist. The same applies to several of the other disciplines represented in IUGG. This resolution was discussed by the IAHS Assembly but was withdrawn because of certain difficulties foreseen by delegates from several countries.

### New Officers

H. J. Peters reports that a major change was made in the way the officers of the commissions of the association are selected. In the past, nominations for all IAHS officers and all commission officers were submitted to the Nominating Committee, which prepared a slate of nominees presented to the plenary session.

Under the new system, agreed upon at Exeter in 1982, ratified at the plenary session on August 15, 1983, and used, for the first time, at the Hamburg assembly, commission officers are elected at the individual plenary meetings of the commissions and these elections are not subject to review or ratification by the IAHS plenary meeting.

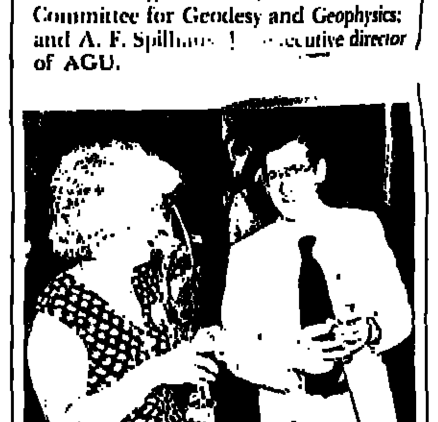
This change is expected to produce improved continuity of officers and greater autonomy for the commissions. The IAHS Nominating Committee reviewed the commissions' slates of nominees prior to announcements to assure geographical balance in the IAHS as a whole.

There were several female nominees for association and commission offices but none were among those presented by the Nominating Committee. Mark Meier, outgoing IAHS president, remarked that women had not been included and said he hoped that in the future he would be able to address the IAHS Bureau as "Ladies and Gentlemen."

The following IAHS officers were elected for 1983–1987 during the administrative sessions at Hamburg. They are G. Kovacs, president; I. Rodriguez-Iturbe, first vice president; V. M. Kotliakov, second vice president; N. B. Ayibotele, third vice president; J. C. Rodda, secretary general; H. C. Riggs, treasurer; and T. O'Donnell, editor.

The following commission and committee presidents and secretaries were elected: **International Commission on Continental Erosion:** D. E. Walling president and R. F. Hadley secretary. **International Commission on Groundwater:** H. J. Colenbrander president and S. M. Gorelick secretary. **International Commission of Snow and Ice:** L. Lliboutry president and G. Wakahama secretary. **International Commission on Surface Water:** H. Liebscher president and A. Szollosi-Nagy secretary. **International Commission on Water Quality:** G. Matthess president and D. Rickert secretary. **International Commission on Water Resource Systems:** M. Hamlin president and L. T. Gottschalk secretary. **International Committee on Remote Sensing and Data Transmission:** A. I. Johnson president and B. E. Goodison secretary.

Talking at the exhibit area of the 18th General Assembly of IUGG in Hamburg last August were *(left to right)* George D. Garland, president of IUGG; H.-J. Duerbaum, acting chairman, FRG National Committee for Geodesy and Geophysics; and A. F. Spilhaus, Jr., executive director of AGU.



Enjoying a social hour at Hamburg's Rathaus during the IUGG General Assembly last August were Penny Kisslinger (wife of AGU Foreign Secretary and IUGG Bureau Member Carl Kisslinger) and Keith Cole, President of IAGA.

## International Association of Geodesy

### Overview

The International Association of Geodesy program at the 18th General Assembly of IUGG featured six special symposia: "The Role of Gravimetry in Geodynamics," "Geodynamic Aspects of the Earth's Rotation," "Improved Gravity Field Estimates on a Global Basis," "Geodetic Reference Systems," "Strategies for Solving Geodetic Problems in Developing Countries," and "The Future of Terrestrial and Space Methods for Positioning." The papers are expected to be published as symposia proceedings by the Department of Geodetic Science and Surveying, Ohio State University, early in 1984.

An active and exciting subject area is the study of earth rotation. Advanced observational techniques are routinely producing polar motion and UT1 determinations having temporal and spatial resolutions three to ten times better than the classical optical observations used by the International Polar Motion Service and the Bureau International de l'Heure. The National Geodetic Survey/NASA POLARIS results are widely recognized as the best available and are used as the "standard" to which other results are to be compared. Studies of the atmosphere's (wind and pressure) role in polar motion and variations in the spin rate are the center of attention. Presentations on this subject were quite convincing relative to the dominance of the mechanism. A special study group was established under the presidency of Jean Dickey, Jet Propulsion Laboratory, to focus on this issue, and two of the IUGG resolutions (*Eos*, October 4, 1983, p. 582) pertain to this issue.

Another interesting highlight was the presentation by Bernd Richter, Institut für Angewandte Geodäsie, on "Tide Spectrum." It appears that the cryogenic gravity meter record there contains a clear signature of polar motion; Richter only compared the record to the BIH polar motion series, but a very preliminary look at the structure in the residuals suggests that the gravity meter may have detected smaller-scale polar motion features observed by the more advanced techniques, i.e., VLBI and SLR.

It has been a truism that at previous IUGG General Assemblies the European geodesists concentrated on theory, while Americans emphasized new technology. In general, this separation now seems to be much less pronounced. There is a much closer community of interests among these groups compared to years ago. The interest of Europeans in Very Long Baseline Interferometry, Global Positioning Systems, etc. is now very strong, and they are eager to apply these new methods, developed in the U.S., as efficiently as possible.

In the same vein, whereas at previous general assemblies the role of countries other than those in North America or Europe was negligible, other parts of the world, especially Japan and China, are proving themselves prominent participants in the geodetic community. The so-called developing countries are also asserting quite loudly their geodetic requirements (e.g., African Doppler Survey). All this means that international cooperation is more important than ever in sharing resources and information, both at individual and organizational levels.

A major problem at the meeting was that the amount of business transacted was so great that a participant, despite a 14-hour day, could absorb only a small fraction of the available program. There were numerous expressions of frustration that attendees missed more sessions than they could attend. Some first-time attendees discovered that geodesy is a branch of science which is much more popular outside the U.S. than within.

Three U.S. representatives were elected to important offices of the IAG: Ivan I. Mueller (Department of Geodetic Science and Surveying, Ohio State University) as first vice president; John D. Bossler (NOAA/NOS) as president of the section of positioning; and Richard Anderle (Naval Surface Weapons Laboratory) as president of the section on advanced space technology (see list below for these and other new IAG officers). The first vice president is a member of the IAG Bureau, while the section presidents are members of the Executive Committee. The fact that three Americans were elected to the Executive Committee is most unusual and reflects the dominant role that Americans play in international geodesy at this time.

The IAG delegates approved 17 IAG and 6 IUGG resolutions, including statements of the currently most accurate geodetic constants, recommendations for location of collocated observations stations for different survey methods, a plea for the release of restricted gravity data, etc. (see list of IAG resolutions below).

John Wahr (age 26) of the University of Colorado won the esteemed Bomford Award, a prize for scientists under 40.

Ivan I. Mueller
*Ohio State University*

### Resolutions

Reproduced below are resolutions adopted by IAG during the 18th General Assembly of the International Union of Geodesy and Geophysics (IUGG) in Hamburg, August 15–27, 1983.

The resolutions passed at each quadrennial general assembly of IUGG and of its member associations are an important barometer of current opinion in the geophysics community and can be a powerful tool in the development of the scientific programs to which they are addressed. The resolutions will help advance programs, however, only if they are used. Carried back home by the national committees which make up the IUGG, the resolutions can spread information worldwide on programs that promise to most effectively advance geophysical knowledge. IUGG and its member associations intend that member groups will present the resolutions before deliberative bodies and otherwise use them to make decision makers aware of international scientific thought.

The 19 resolutions adopted by IUGG as a whole appeared in *Eos*, October 4, 1983, p. 582.

The International Association of Geodesy,

1. Recognizing its responsibility for providing representative estimates for fundamental geodetic parameters to the scientific community, and having decided to update current numerical values at each General Assembly, recommends that the following numerical values be considered currently representative estimates:

- velocity of light in vacuo: $c = (299{,}792{,}458 \pm 1.2)\ \mathrm{m\ s^{-1}}$
- Newtonian gravitational constant: $G = (6673 \pm 1) \times 10^{-14}\ \mathrm{m^3\ s^{-2}\ kg^{-1}}$
- angular velocity of the earth (rounded value): $\omega = 7{,}292{,}115 \times 10^{-11}\ \mathrm{rad\ s^{-1}}$
- geocentric gravitational constant including the atmosphere: $GM = (39{,}860{,}044 \pm 1) \times 10^7\ \mathrm{m^3\ s^{-2}}$
- geocentric gravitational constant of the atmosphere only: $GM_A = (35 \pm 0.3) \times 10^7\ \mathrm{m^3\ s^{-2}}$
- second degree harmonic coefficient (free from permanent tidal deformation): $J_2 = (1{,}082{,}629 \pm 1) \times 10^{-9}$
- equatorial radius of the earth: $a = (6{,}378{,}136 \pm 1)\ \mathrm{m}$
- equatorial gravity: $\gamma_e = (978{,}032 \pm 1) \times 10^{-5}\ \mathrm{m\ s^{-2}}$
- flattening ($f$): $1/f = (298{,}257 \pm 1) \times 10^{-3}$
- geoidal potential: $W_0 = (6{,}263{,}686 \pm 2) \times 10\ \mathrm{m^2\ s^{-2}}$
- triaxility parameters (rounded values)— equatorial flattening ($f_1$): $1/f_1 = 90{,}000$; longitude of major axis of equatorial ellipse: $\lambda_1 = 15°\mathrm{W}$

The value of $c$ and its standard error are taken from the CODATA System of Physical Constants of 1973. The other standard errors are intended to represent realistic estimates of accuracy, and the value of $\omega$ is accurate to the given digits.

It is remarked that more details on basic geodetic parameters are found in the Report of SSG 5.39 presented at this General Assembly.

It is particularly emphasized that these values are current estimates, whereas for reference purposes the Geodetic Reference System 1980, as adopted by the IUGG at the 17th General Assembly should be used.

2. Recognizing the importance in mountain areas of precise geoid determination by a combination of astrogeodetic, gravimetric and other data, and noting the progress achieved in this respect in various regions and the development of new observational and theoretical methods, recommends the active continuation of this work and its support by national authorities.

3. Noting the existence of global and regional scientific programs using space techniques for positioning, such as MERIT/COTES and the crustal dynamics project initiated by NASA, and recognizing the significance of such programs for long-term studies and dynamic investigations of the earth and its environment, and considering that: (1) the success of such programs critically depends on the establishment and maintenance of networks of terrestrial observing stations, and (2) such stations may be intermittently occupied by a variety of instrumentation over a total time span of possibly several decades or longer, strongly urges the countries involved in such establishment and maintenance to devote utmost care to station selection, monumentation and survey strategy, so as to enable unambiguous reoccupation to an accuracy compatible with the scientific objectives of the programs.

4. Noting that: (1) a better knowledge of the gravity field is essential for the application of the next generation of altimetric satellites to the study of ocean dynamics, and (2) many areas of the world have no gravity survey, including areas of great importance to the understanding of the earth's structure and evolution, and (3) many other areas do not have adequate gravity cover; considering that such improved gravity field information can most practically be obtained from dedicated satellite missions using satellite-to-satellite tracking or gravity gradiometry; recommends that all countries involved with space programs give high priority to such satellite missions.

5. Recognizing the important role that global satellite laser and radio tracking systems will have in the computation of precise orbits for future geodetic and oceanographic satellites, and noting that topics of central concern to orbit analysis are the determination of (1) the appropriate terrestrial reference frames for describing the tracking stations locations, (2) the precise locations of the individual tracking stations in these reference frames, and (3) any scale and/or relative origin bias in the independent reference frames of the laser and radio tracking data, and considering the need for data from such systems grouped at common sites to resolve any scale and/or origin bias, recommends that particular efforts be made to group radio and laser tracking systems at common sites during future international tracking campaigns with emphasis on achieving global coverage for the collocated systems.

6. Recognizing the general need for establishing orbits for altimeter satellites in support of investigations in geodesy and oceanography, and noting (1) the particular contributions that such altimeter satellites as ERS-1, Poseidon and TOPEX may make to efforts to understand the general ocean circulation, and (2) that all these satellites are planned to be in orbit during the same period (1987–1991), recommends that cooperative global tracking campaigns be organized to provide the data sets for precise orbit computations for the satellites.

7. Recognizing the increasing importance of precise, space-related positioning systems such as those of laser ranging and very long baseline interferometry (VLBI) for investigations of the kinematics and dynamics of the earth and its environment, recommends that national authorities extend their support for the development and operation of these systems.

8. Recognizing that the study of many geophysical phenomena in the 200–2000-km range of wavelength is severely handicapped by large gaps in the available surface gravity coverage, especially over land, urges all countries to release their land gravity measurements to the scientific community via the International Gravity Bureau; if national interests prevent the release of detailed data, national agencies are requested to release 1° × 1° mean values of free-air gravity anomalies and elevations, which are of fundamental importance for global scientific pursuits.

9. Recognizing the high level of accuracy of both absolute and relative gravity measurements recently attained, considering the necessity to adopt standard corrections to gravity observations in order to allow intercomparisons between measurements at different epochs of time; recommends (1) that the tidal correction applied to the gravity observations follow the final recommendations of the Standard Earth Tide Committee as presented at the 18th IUGG General Assembly; (2) that the atmospheric pressure corrections refer to a common Standard Atmosphere, the sensitivity coefficient being $-0.310\ \mathrm{\mu m\ s^{-2}/mbar}$ ($-0.3\ \mathrm{\mu Gal/mbar}$), unless it is determined by special investigations, in which case the value used must be published together with the results. The closed formula for the computation of this Standard Atmosphere will be published in a future issue of the Bulletin d'Information du Bureau Gravimétrique International with the corresponding numerical tables and the programing code; and (3) that the gravity gradient corrections be published with the adopted local gradient and/or the adopted height difference so that the original values may be recovered.

10. Recognizing that techniques of repeated relative gravity measurement have achieved increased accuracy and have been applied (1) as a fast and efficient tool to detect and investigate gravity changes associated with recent crustal movements, (2) in combination with other techniques such as leveling and VLBI to give a deeper insight into the underlying dynamic processes, and (3) as an element in earthquake prediction research, and noting the success of recent campaigns in various parts of the world, recommends that high priority be given to this research.

11. Recognizing that the physical interpretation of time variations of the natural coordinates, height above sea level, and astronomic latitude and longitude requires knowledge of the time variation of the earth's gravity field, and considering that this latter can be determined by a world-wide net of gravity stations with repeated precise observations of absolute gravity and height above the current mean sea level, recommends that efforts be made to observe and reobserve a large number of such stations favorably distributed around the globe.

12. Recognizing the importance of the optimal design of geodetic networks in one, two, or three dimensions, recommends that research in the following fields be encouraged: development of criterion matrices; investigation of mathematical cost functions reflecting real costs of observing geodetic networks; and realization of operational software.

13. Recognizing the fundamental role of the geodetic boundary value problems in establishing gravity field approximations on a sound theoretical basis as well as in producing quick and stable first order solutions, and noting the progress made in this field, recommends (1) that analysis of fundamental problems such as the Molodensky problem be pursued to a reasonable conclusion, including nonlinear cases; (2) that newly defined mixed boundary value problems, especially those of altimetry-gravimetry, be investigated with numerical examples to establish the applicability of solutions; and (3) that geodynamic boundary value studies, begun over the last few years, now model the mechanics of planet earth in a unified field theory.

14. Recognizing recent studies of the local mathematical properties of the earth's gravity field using differential methods in such a way that geodynamical implications are included, and considering similar studies in the other associations of IUGG, recommends that these studies be intensified and appropriate interdisciplinary contacts established.

15. Recognizing the importance and feasibility of several kinds of investigations which could lead to major progress in the interdisciplinary field of tidal friction and earth's rotation, (1) that theoretical models of paleotides be computed in as narrow time steps as possible (10 million years or smaller for the Phanerozoic), using recent results for continental drift in the Proterozoic for approximate models, and exploring, for earlier times, the total variability of the tidal torque, with different schematic geometries of the oceans; (2) that despite the dominating role of oceanic tides within the last aeons, the rheology of the solid earth be carefully searched for areas in which an "old" earth could differ remarkably from the present earth; and (3) that further geodetic, astronomical, and geological investigations be encouraged in order to enlarge the data base for the study of the earth's rotation

16. Recognizing the need for the uniform treatment of tidal corrections to various geodetic quantities such as gravity and station positions, and considering the reports of the Standard Earth Tide Committee and SSG 2.55 Predictive Methods for Space Techniques, presented at the 18th General Assembly, recommends that (1) the rigid-earth model be the Cartwright-Tayler-Edden model with additional constants specified by the International Center for Earth Tides, (2) the elastic earth model be that described by Wahr using the 1066 A model earth of Gilbert and Dziewonski, (3) the indirect effect due to the permanent yielding of the earth be not removed, and (4) ocean loading effects be calculated using the tidal charts and data produced by Schwiderski as working standards.

17. Recognizing the excellent organization of the Hamburg General Assembly, and the efficient administrative arrangements which made an invaluable contribution to its scientific success, expresses its grateful thanks to its German hosts for their successful efforts in making its meeting so pleasant and scientifically profitable.

### Officers

**Bureau**

*President:* P.-V. Angus-Leppan (Australia); *First Vice President:* I. I. Mueller (USA); *Secretary General:* M. Louis (France)

**Sections, Commissions, Special Study Groups, Permanent Services**

**Section 1: Positioning**

*President:* J. D. Bossler (USA); *Secretaries:* H. Henneberg (Venezuela), M. Prilepin (USSR), J. Y. Chen (China)

**Commission 10: Continental Networks**

*President:* J. Kakkuri (Finland)

**Subcommissions**

European Triangulation (RETRIG): *President,* K. Poder (Denmark); *Secretary,* Deutsches Geodätisches Forschungsinstitut (FRG). European Leveling (UELN): *President,* A. Waalewinn (Netherlands); *Secretary,* E. Gubler (Switzerland). North America: *President,* J. D. Bossler (USA); *Secretary,* D. MacLellan (Canada). South America: *President,* D. Ferrari (Brazil); *Secretary,* J. Muñiz (Chile). Southeast Asia and Pacific: *President,* C. Veenstra (Australia); *Secretary,* J. Rais (Indonesia). Indian Subcontinent: *President,* M. G. Arur (India). Western Asia: *President,* R. Majali (Jordan).

**Special Study Groups**

1–59, Computer assisted design of geodetic networks: *President,* W. Baran (Poland). 1–72, Marine positioning: *President,* D. E. Wells (Canada). 1–73, Integrated geodesy: *President,* G. W. Hein (FRG). 1–74, Comparison of methods of analysis and evaluation of leveling errors: *President,* A. M. Wassef (Egypt). 1–75, World vertical reference system: *President,* R. H. Rapp (USA). 1–76, Positioning with GPS: *President,* C. Goad (USA). 1–77, Utilization of inertial techniques for geodesy: *President,* K. P. Schwarz (Canada). 1–78, Atmospheric effects on terrestrial geodetic measurements: *President,* H. Kahmen (FRG). 1–79,

AGU (cont. on p. 970)

AGU *(cont. from p. 969)*

Optical long base interferometry for geodesy and geodynamics: *President*, M. Prilepin (USSR).

**Section 2: Advanced Space Technology**

*President*: R. Anderle (USA); *Secretaries*: B. Kolaczek (Poland), P. Wilson (FRG)

**Commission 8: International Coordination of Space Techniques for Geodesy and Geodynamics**

*President*: I. I. Mueller (USA), until June 1984; C. Reigber (FRG), after June 1984

**Special Study Groups**

2-54, Satellite radio-tracking techniques: *President*, B. E. Schutz (USA). 2-81, Specification of methods for handling systematic errors arising from satellite laser ranging instrumentation: *President*, J. Gaignebet (France). 2-82, Compression and smoothing of data obtained from space techniques: *President*, D. Lelgemann (FRG). 2-83, Data analysis methods for satellite-to-satellite tracking and satellite gradiometry: *President*, R. Rummel (Netherlands). 2-84, Atmospheric effects on geodetic space measurements: *President*, F. Brunner (Switzerland).

**Section 3: Determination of the Gravity Field**

*President*: W. Torge (FRG); *Secretaries*: C. Tscherning (Denmark), I. Nakagawa (Japan)

**Commission 3: International Gravimetric Commission**

*President*: J. Tanner (Canada)

**Special Study Groups**

3-85, Comparison of high-precision relative gravimetry techniques: *President*, E. Groten (FRG). 3-86, Evaluation of absolute gravity measurements: *President*, Y. Boulanger (USSR). 3-87, Development of a new world absolute gravity network: *President*, G. Boedecker (FRG). 3-88, Determination of the geoid in Europe: *President*, C. Birardi (Italy). 3-89, Observation and adjustment procedures in dynamic gravimetry: *President*, J. Makris (USA). 3-90, Evaluation of local gravity field determinations: *President*, C. Tscherning (Denmark).

**Section 4: General Theory and Methodology**

*President*: E. Grafarend (FRG); *Secretaries*: K. P. Schwarz (Canada), F. Sanso (Italy)

**Special Study Groups**

4-56, Differential geometry of the gravity field: *President*, E. Livieratos (Greece). 4-57, Boundary-value and convergence problems in physical geodesy: *President*, P. Holota (Czechoslovakia). 4-60, Statistical methods for estimation and testing of geodetic data: *President*, D. Fritsch (FRG). 4-66, Geodetic data base management: *President*, A. Frank (USA). 4-71, Optimal design problems: *President*, G. Schmitt (FRG). 4-91, Local gravity field approximation: *President*, H. Sunkel (Austria). 4-92, Global gravity field approximation: *President*, L. Sjöberg (Sweden). 4-94, Theory of geodetic reference frames: *President*, J. Wahr (USA). 4-95, Multi-body force function—geodetic aspects of astrodynamics: *President*, M. Sidlichovsky (Czechoslovakia). 4-96, Models for time-dependent geodetic positioning: *President*, P. Vaníček (Canada).

**Section 5: Geodynamics**

*President*: H. Kautzleben (GDR); *Secretaries*: H. Kahle (Switzerland), D. MacCarthy (USA)

**Commission 5: Earth Tides**

*President*: J. Kuo (USA); *Secretary*: P. Melchior (Belgium)

**Commission 7: Recent Crustal Movements**

*President*: P. Vyskočil (Czechoslovakia)

**International Center of Earth Tides (affiliated to FAGS)**

*Director*: P. Melchior (Belgium)

**International Polar Motion Service (affiliated to FAGS)**

*Director*: K. Yokoyama (Japan)

**International Service of Mean Sea Level (affiliated to FAGS)**

*Director*: D. T. Pugh (UK)

**Bureau International de l'Heure (affiliated to FAGS)**

*Director*: B. Guinot (France)

**International Center of Recent Crustal Movements**

*Director*: P. Vyskočil (Czechoslovakia)

**Special Study Groups**

5-97, Gravity anomalies and geodynamics of mountain belts: *President*, H. Kahle (Switzerland). 5-98, Atmospheric excitation of earth's rotation: *President*, J. O. Dickey (USA). 5-99, Tidal function and earth rotation: *President*: M. Burša (Czechoslovakia). 5-100, Parameters of common relevance of astronomy, geodesy, and geodynamics: *President*, B. H. Chovitz (USA).

**Out of Section**

**Commission 6: International Geodetic Bibliography**

*President*: L. Stange (GDR); *Secretary*: C. Boucher (France)

**Commission 9: Education in Geodesy**

*President*: E. Krakiwsky (Canada)

**Commission 11: Geodesy in Africa**

*President*: A. Cisse (Côte d'Ivoire); *Secretary*: O. Fadahunsi (Nigeria)

**Special Study Group 0-67: History of Geodesy**

*President*: C. Whitten (USA)

**Other Official Positions**

*Immediate Past-President*: H. Moritz (Austria); *Second Vice-President*: M. Burša (Czechoslovakia); *Third Vice-President*: G. Lachapelle (Canada); *Editor in Chief of the Bulletin Géodésique*: I. I. Mueller (USA), *Assistant Secretaries*: C. Boucher (France), K. Daugherty (USA), J. Krynski (Poland); *Honorary Presidents*: C. Whitten (USA), G. Bomford (UK), A. Marussi (Italy), Y. Boulanger (USSR), T. J. Kukkamäki (Finland), and H. Moritz (Austria); *Honorary Secretary General*: J. J. Levallois (France)

The Executive Committee consists of the Bureau, the Immediate Past-President, the Vice Presidents, and the Presidents of Sections.

The secretaries of Sections, the editor-in-chief of the *Bulletin Géodésique*, the assistant secretaries, the honorary president, and secretary general may attend the meetings of the Executive Committee, with voice but without vote.

## AGU Legislative Guide Available

A guide to help AGU members communicate with legislators and government agency officials is available free of charge from AGU headquarters. The guide is based on the premise that input from the scientific community assists government to make decisions based on the latest factual information available.

*AGU's Guide to Legislative Information and Contacts* was developed by AGU's Committee on Public Affairs and is based largely on a publication of the American Institute of Biological Sciences. The guide briefly outlines the key steps in the legislative process and lists sources of information on legislation. The booklet also provides guidelines for corresponding with legislators and for providing scientific testimony to Congress. It also delineates some of the constraints under which AGU must operate when undertaking legislative activities.

The booklet spells out how to get copies of bills, hearings proceedings, committee reports, laws, government regulations, and legal notices. Copies of bills, for example, may be requested from the legislator who introduced the bill or from the House or Senate Documents Room. The *Congressional Record* also carries the text of bills introduced. Staff members of congressional committees, though quite busy, often are good sources of information. Names and addresses of legislators, congressional committees, and executive officials can best be gleaned from the *Congressional Directory* and *The United States Government Manual*, the guide says. Both are available from Government Printing Office (GPO) bookstores, which are located in 11 cities nationwide. To obtain a list of the locations, write to the Superintendent of Documents, Washington, DC 20402.

In addition to obtaining information about current legislation, AGU members may wish to express their opinions as individuals on pending legislation affecting geophysics. Letters from scientists who know the implications of issues and are familiar with the local situation can be especially valuable to legislators in considering how to vote on important issues. To be most effective, the new AGU guide recommends, letters to congressmen should be courteous, brief, to the point, and should address one issue per letter. Familiarity with the specifics of proposed legislation before reacting to it is essential.

### Lecturers for AGU Science and Policy Seminars Sought

AGU is establishing a series of Science and Policy Seminars. AGU members who have worked with public policy issues involving geophysics are invited to share with university students and faculty their experiences, insights, and expertise. For guidelines on this new and exciting program and application information, write or call:

**AGU Member Programs**
2000 Florida Avenue, N.W.
Washington, D.C. 20009
(202) 462-6903

One section of the guide offers suggestions on how to present scientific testimony at a congressional hearing. Among the basics: Orient testimony to the issue being discussed; be brief and direct; avoid jargon and mathematics; and keep the presentation simple. Conclusions based on scientific investigations receive more attention than the route by which the conclusions are reached. It is important, the guide explains, to distinguish between facts and value judgments. Specific guidelines are given for testimony that is being presented with the endorsement of AGU and testimony that is not endorsed by the Union as a whole.

Options for a scientific society such as AGU to provide information to Congress also are delineated by the guide. AGU can choose to endorse testimony; can arrange for written or verbal testimony by an expert; can join with other interested groups to develop and present testimony on mutual concerns; or can opt not to present testimony. The guide itemizes limitations of involvement by AGU based on AGU's tax-exempt status.

Based on the publication *A Guide for Providing Scientific Testimony* by Arthur Jack Grimes of the American Institute of Biological Sciences, the guide also reviews the AGU Council's position concerning AGU's role in advocacy on public issues (*Eos*, August 2, 1983, p. 488).

For more information about the guide, contact AGU Member Programs at AGU headquarters (telephone: 202-462-6903)—*BTR*

# Meetings

## Meeting Report

### Ground-Based Optical Aeronomy

The direction of scientific research in ground-based optical aeronomy in the 1980's was the subject of an August 1–4, 1983, workshop under the sponsorship of the National Science Foundation. Held at Utah State University with 60 scientists, the workshop reviewed the scientific problems and discussed the ground-based optical facilities required to attain the scientific objectives over the next solar cycle. The need for a coordinated research program for future progress was identified.

The first 2 days of the workshop provided a review of ongoing individual research projects and gave the attendees a good idea of the overall scope of the North American optical aeronomy research program. These reviews demonstrated that the research efforts could be separated into three main scientific topics: airglow and auroral physics, atmospheric dynamics, and space plasma physics. Each of these research areas uses, as a primary research tool, a different observational technique, such as spectrometers, interferometers, and monochromatic images. On the third day, the workshop attendees divided into five sections to prepare a 5 year plan. The following spokespersons were selected:

G. Deehr, University of Alaska, Fairbanks, high latitude studies
D. Torr, Utah State University, Logan, mid-low latitude studies
G. Hernandez, NOAA, Boulder, dynamics
R. Eather, Boston College, Chestnut Hill, space plasma physics
R. Roble, NCAR, Boulder, central data systems

The final report will be edited by G. Romick, University of Alaska, Fairbanks, and L. Broadfoot, University of Arizona, Tucson. Additional input from the scientific community for inclusion in the report should be directed to the appropriate person listed above.

In the past most aeronomy research has been pursued by individual research efforts at various locations. It was generally agreed that the approach for the 1980's should be to augment that effort by the coordination of the ground-based optical measurements in time and space and, where appropriate, from multiple locations. Coordination with other disciplines, including radar backscatter, rocket probes, and satellite overflights, will be important in establishing a consistent picture between global and local atmospheric processes and reactions.

The coordinated program, organized to complement, enhance, and relate independent research projects, will include:

(1) collection of parameters and models of present understanding of airglow and auroral physics to provide a consistent scientific data base on which to build; and

(2) preparation of observational facilities which will make optimum use of modern technological developments in detectors, computers, and data management/distribution systems.

*This meeting report was prepared by A. Lyle Broadfoot, who is with the Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85713.*

## Announcements

### Water Management

The International Association for Hydraulic Research and the United Nations Educational, Scientific, and Cultural Organization will hold a Seminar on Water Management Practice in Zaria, Nigeria, July 30–August 2, 1984. Papers should be submitted for the seminar by January 1984.

Meeting topics will include water resources management, socio-economic problems (particularly in developing countries) in water management, rural water supply development, and models for water demand analysis, for water allocation, and for water quality management.

Inquiries should be addressed to Gunnar Lindh, Department of Water Resources Engineering, Lund Institute of Technology, Fack 725, S-220 07 Lund, Sweden.

### Aerospace Sciences

The American Institute of Aeronautics and Astronautics (AIAA) will hold its 22nd Aerospace Sciences Meeting in Reno, Nev., January 9–12, 1984. Speakers for the meeting's space sciences and astronomy program will present first results from Spacelab 1; they will also discuss planetary exploration through the year 2000, low-cost missions and new techniques, scientific research on earth sensing missions, and solar-terrestrial physics research missions. There will be a poster session on space transportation research opportunities and future missions and on the AIAA Shuttle Environment and Operations Conference, as well as a special presentation on results from the Infrared Astronomical Satellite (IRAS).

More information on the conference or planned speakers is available from Paul Mizera, The Aerospace Corporation, MS: M2/260, P.O. Box 92957, Los Angeles, CA 90009 (telephone 213-648-6514) or Jag Singh (telephone 804-865-3907).

### Magnetosphere-Ionosphere Connection

In connection with the 25th plenary meeting of the ICSU Committee on Space Research (COSPAR) there will be a symposium on the physics of the magnetosphere-ionosphere connection in Graz, Austria, July 2–5, 1984. Abstracts are due by January 15.

Tentative topics for discussion include a review of models and theories of coupling processes, high-latitude dynamics of ions and neutrals, particle interchange between ionosphere and magnetosphere, momentum transfer, plasma convection, current systems, equatorial and low-latitude phenomena, electric fields and particle acceleration, auroras as indicators of magnetospheric activity, and metrics and asymmetries between northern and southern hemispheres, micropulsations, and solar modulations. There also will be a session comparing earth with other planets.

For more information, or to submit an abstract, contact E. R. Schmerling, EE-8 NASA Headquarters, Washington, DC 20546.

## Geophysical Year

**The following abbreviations are used in the Geophysical Year calendar.**

AAAS American Association for the Advancement of Science
AAPG American Association of Petroleum Geologists
ACS American Chemical Society
AIPG American Institute of Professional Geologists
AMS American Meteorological Society
ASCE American Society of Civil Engineers
AWRA American Water Resources Association
GSA Geological Society of America
IAG International Association of Geodesy
IAGA International Association of Geomagnetism and Aeronomy
IAHR International Association for Hydraulic Research
IAHS International Association of Hydrological Sciences
IAMAP International Association of Meteorology and Atmospheric Physics
IAPSO International Association for the Physical Sciences of the Ocean
IASPEI International Association of Seismology and Physics of the Earth's Interior
IAVCEI International Association of Volcanology and Chemistry of the Earth's Interior
ICSU International Council of Scientific Unions
IUGG International Union of Geodesy and Geophysics
IUGS International Union of Geological Sciences
IWRA International Water Resources Association
MSA Mineralogical Society of America
SEG Society of Exploration Geophysicists
SEPM Society of Economic Paleontologists and Mineralogists
URSI International Union of Radio Science
WMO World Meteorological Organization

**Future AGU Meetings**

*Fall Meetings*
Dec. 3–7, 1984, San Francisco (*Abstracts due mid-September 1984*)
Dec. 9–13, 1985, San Francisco (*Abstracts due mid-September 1985*)

*Ocean Sciences Meeting*
Feb. 20–24, 1984, New Orleans

*Spring Meetings*
May 14–18, 1984, Cincinnati (*Abstracts due February 22, 1984*)
May 27–31, 1985, Baltimore (*Abstracts due early March 1985*)

## 1983

Dec. 12–13 **Conference on Advances in Infiltration**, Chicago, Ill. Sponsors, American Society of Agricultural Engineers, AGU. (J. L. Nieber, Program Chairman, Dept. of Agricultural Engineering, Texas A&M Univ., College Station, TX 77843.)

Dec. 15–17 Second Annual Meeting of the Working Group on **Mediterranean Ophiolites**, Florence, Italy. (Giovanni B. Piccardo, Instituto di Mineralogia, Petrographia e Geochimica-Università, via La Pira 4, 50121 Firenze, Italy.)

## 1984

Jan. 9–13 *Chapman Conference on Natural Variations in Carbon Dioxide and the* **Carbon Cycle**, Tarpon Springs, Fla. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

January 10–11 Computer Applications in **Mineral Exploration**, Toronto, Canada. Sponsors, Toronto Geological Discussion Group, Geological Assoc. of Canada, Canadian Institute of Mining and Metallurgy, Canadian Exploration Geophysical Society, and Association of Exploration Geochemists. (The Organizing Committee, CAME 1984, c/o Samim Canada Ltd., Suite 2116, 130 Adelaide St. W., Toronto, Canada M5H 3P5.)

Jan. 11–14 National Meeting of the International Union of Radio Science (URSI), Boulder, Colo. Sponsor, U.S. National Committee of URSI. (T. E. Van Zandt, NOAA/ERL, R/E/AL3, 325 Broadway, Boulder, CO 80303; tel.: 303-497-3854.)

Jan. 16–20 Microwave Signatures in **Remote Sensing**, URSI, Toulouse, France. Sponsors, Centre National d'Étude Spatiales, with the participation of URSI Commission F and the Centre d'Étude Spatiale des Rayonnements (CESR). (Technical program, Erwin Schanda, Universität Berne, Institute of Applied Physics, Sidlestrasse 5, 3012 Berne, Switzerland or Richard K. Moore, Remote Sensing Laboratory, Univ. of Kansas Center for Research, Inc., 2291 Irving Hill Drive-Campus West, Lawrence, KS 66045. Registration, F. Cambou, Head, CESR, 9 Avenue du Colonel Roche, B.P. 4346, 31029 Toulouse-Cedex, France.)

Jan. 16–21 Penrose Conference on the Evolution of the **Central Atlantic Ocean and its Continental Margins**, Giens, France. (J. Sougy, Laboratoire de Géologie Dynamique, LA CNRS no. 132, Faculté des Sciences de Saint Jérôme, 13397, Marseille Cedex 13, France; tel.: (91) 98 90 10, ext. 510.)

Jan. 23–27 **Ocean Sciences Meeting**, New Orleans, La. (John R. Apel, Assistant Director for Planning, Johns Hopkins Univ., Applied Physics Laboratory, Johns Hopkins Rd., Laurel, MD 20707.)

Jan. 30–Feb. 3 Conference on **Planetary Plasma Environment**, Yosemite, Calif. Sponsors, NASA, AGU. (J. H. Waite, NASA/Marshall Space Flight Center, tel.: 205-453-3037; or C. R. Clauer, Stanford Univ., tel.: 415-497-4691.)

Feb. 7–8 **Subsurface Investigations Conference**, Surface and Borehole Geophysics, San Antonio, Tex. Sponsor, National Water Well Association. (NWWA, 500 W. Wilson Bridge Rd., Worthington, OH 43085; tel.: 614-846-9355.)

Feb. 9–14 International Symposium on **Recent Crustal Movements of the Pacific Region**, Wellington, New Zealand. Sponsor, Royal Society of New Zealand. (Secretary, H. M. Bibby, Geophysics Division, DSIR, P.O. Box 1320, Wellington, New Zealand.)

Feb. 20–24 Chapman Conference on **Collisionless Shock Waves in the Heliosphere**, Napa, Calif. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

Feb. 21–24 **South East Asia Petroleum Exploration Society** (SEAPEX) Meeting with Fifth Offshore Southeast Asia Conference and Exhibition (OSEA), Singapore. (J. MacDonald, OSEA, 6-E Mt. Sophia, Singapore 0922; tel.: 337-3476; telex: RS 20107 TRSHOW.)

Feb. 23–24 15th Meeting, **International Erosion Control Association**, Denver, Colo. (International Erosion Control Association, Inc., P.O. Box 807, Freedom, CA 95019; tel.: 408-688-3228.)

March 11–16 American Society of **Photogrammetry** and the American Congress on **Surveying and Mapping** National Meeting, Washington, D.C. (Thomas J. Lauterborn, Rte. 1, Box 127, Waterford, VA 22190; tel.: 703-882-3334.)

March 12–16 15th Annual **Lunar and Planetary Science Conference**, NASA Johnson Space Center, Houston, Tex. Sponsors AGU, Lunar and Planetary Institute, Meteoritical Society, and American Astronomical Society. (15th Lunar and Planetary Science Conference Office, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058; tel.: 713-486-2150.)

March 13–15 Fourth Biennial SEG/U.S. Navy Joint Technical Symposium on **Three-Dimensional Marine Data Collection, Processing, Interpretation, and Presentation**, National Space Technology Laboratories (NSTL), Bay St. Louis, Miss. (J. A. Ballard, Chairman, NORDA, NSTL, MS 39529; tel.: 601-688-4760)

March 14–17 1984 GSA Meeting, **Hydrogeology** Division, Northeast Section, Providence, R. I. (Jeff Sgambat, Garaghty and Miller, Inc., 844 West St., Annapolis, MD 21401; tel.: 301-268-7730.)

March 19–23 Fifth **Northern Research Basins** Symposium and Workshop, Vierumaki, Finland. (Charles Slaughter, Chairman, U.S. Working Group, Institute of Northern Forestry, USDA Forest Service, 308 Tanana St., Fairbanks, AK 99701, or Olli Faasanen, Secretary, Organizing Committee, Hydrological Office, Box 436, 00101 Helsinki 10, Finland.)

March 19–24 Third International Symposium on **Land Subsidence**, Venice, Italy. Sponsor, IAHS. (A. I. Johnson, Program Chairman, Third International Symposium on Land Subsidence, Woodward-Clyde Consultants, 7600 East Orchard Rd., Englewood, CO 80111.)

March 22–29 Seventh International Symposium on **Equatorial Aeronomy** (ISEA), Hong Kong. Sponsors, ICSU Committee on Space Research, IUGG, IAGA, IAMAP, and URSI. (S. Matsushita, Chairman, ISEA, High Altitude Observatory, NCAR, P.O. Box 3000, Boulder, CO 80307; tel.: 303-494-5151.)

March 26–27 GSA South-Central Section Meeting, Dallas, TX. (Jean Latulippe, Meetings Dept., GSA, Boulder, CO 80301; tel.: 303-447-2020.)

March 28–30 International Symposium on **Earthquake Relief** in Less Industrialized Areas, Zürich, Switzerland. (Swiss National Committee for Earthquake Engineering, SIA Postfach, CH-8039, Zürich, Switzerland.)

April **Arctic Water Pollution Research**: Applications of Science and Technology, Yellowknife, N.W.T., Canada. (W.A. Bridgeo, Bridco Values, Ltd., P.O. Box 3161, Halifax South Post Office, Nova Scotia B3J 3H5, Canada.)

April CSCE/ASCE Cold Regions Engineering Specialty Conference on **Northern Resource Development**, Edmonton, Alberta. (Daniel W. Smith, Dept. of Civil Engineering, University of Alberta, Edmonton, Alberta T6G 2G7, Canada.)

April International Conference on Recent Advances in **Mineral Science and Technology**, Johannesburg, South Africa. Sponsor, South African Council for Mineral Technology (Mintek). (The Conference Secretary (C.25), Mintek, Private Bag X3015, Randburg, 2125 South Africa.)

April 2–4 Second National Symposium and Exposition on **Groundwater Instrumentation**, Las Vegas, Nev. Sponsor, National Well Water Association. (D. M. Nielsen, Conference Coordinator, NWWA, 500 W. Wilson Bridge Rd., Worthington, OH 43085; tel.: 614-846-9355.)

April 3–5 Interdisciplinary Conference on Meeting the **Water Needs of the Southwest**, Dallas, Tex. (Michael A. Collins, School of Engineering and Applied Science, Southern Methodist University, Dallas, TX 75275; tel.: 214-692-3060.)

April 4–6 **GSA** Joint North-Central Section and Southeast Sections Meeting, Lexington, Ky. (Jean Latulippe, Meetings Dept., GSA, Boulder, CO 80301; tel.: 303-447-2020.)

April 8–11 13th Annual **Rocky Mountain Groundwater Conference**, Great Falls, Mont. (W. A. Van Voast, Mont. Bureau of Mines and Geology, 3021 Sixth Ave. North, Billings, MT 59101; tel.: 406-259-9834.)

April 11–13 International Conference on Hydraulic Design in **Water Resources Engineering**: Channels and Channel Control Structures, Southampton, UK. (K. V. H. Smith, Dept. of Civil Engineering, The University, Southampton SO9 5NH, UK.)

April 24–27 Pacific Conference on **Marine Technology** (PACON 84), Honolulu, Hawaii. Sponsor, Marine Technology Society. (PACON 84, Center for Engineering Research, Univ. of Hawaii at Manoa, Honolulu, HI 96822, tel.: 808-948-7338 or 7449.)

April 29–May 4 Penrose Conference on Processes and Products of **Multistage Melting and Metasomatism in the Mantle**, Gold Canyon Ranch, Ariz. Sponsors, GSA and USGS. (J. E. Pike, USGS, 345 Middlefield Rd., MS 75, Menlo Park, CA 94025.)

April 30–May 3 30th Annual Technical Meeting: **Environmental Integration Technology** Today for a Quality Tomorrow, Orlando, Fla. Sponsor, Institute of Environmental Sciences. (Institute for Environmental Sciences, 940 E. Northwest Hwy., Mount Prospect, IL 60056; tel.: 312-255-1561.)

May-June 12th International Congress on **Irrigation and Drainage**, Fort Collins, Colo. (ICID, 48 Nyaya Marg, Chanakyapuri, New Delhi 110012, India.)

May 7–9 Third Symposium on **Arctic Air Chemistry**, Downsview, Ont., Canada. (L. A. Barrie, Atmospheric Environment Service, 4905 Dufferin St., Downsview, Ontario M3H 5T4, Canada, tel.: 416-667-4785; or K. A. Rahn, Graduate School of Oceanography, Univ. of Rhode Island, Narragansett, RI 02882–1197, tel.: 401-792-6234.)

May 14–16 **Geological Assoc. of Canada and Mineralogical Assoc. of Canada** Joint Annual Meeting, London, Ontario. (N. D. MacRae, Dept. of Geology, Univ. of Western Ontario, London, Ontario N6A 5B7, Canada.

May 14–18 **AGU Spring Meeting**, Cincinnati, Ohio. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

May 20–25 International Symposium on **Deep Observation and Sampling of the Continental Crust Through Drilling**, Tarrytown, N. Y. (Barry Raleigh, Director, Lamont-Doherty Geological Observatory, Palisades, NY 10964; tel.: 914-359-2900.)

May 21–25 International **Groundwater Symposium on Groundwater Resources Utilization and Contaminant Hydrogeology**, Montreal, Canada. Sponsors, Canadian National Chapter of the International Association of Hydrogeologists and the Canadian Water Well Association. (A. Kohut, Chairman, International Groundwater Symposium Montreal '84, Ministry of the Environment, 765 Broughton St., Victoria, B. C., V8V 1X5, Canada.)

May 21–25 Symposium on **Climatic History, Periodicity, and Predictability**, New York. (John E. Sanders, Dept. of Geology, Barnard College, Columbia Univ., New York, NY 10017; tel.: 212-280-4812.)

May 23–25 Fourth National Symposium and Exposition on **Aquifer Restoration and Groundwater Monitoring**, Columbus, Ohio. Sponsor, Na-

## International Geophysical Calendar for 1984

**(See other side for information on use of this Calendar)**

| | S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | 8 | 9 | $10^{M}$ | $11^{M}$ | 12 | 13 | 14 |
| JANUARY | 15 | 16 | $17^{+}$ | $18^{+}$ | $19^{+}$ | 20 | 21 |
| | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| | 29 | 30 | 31 | 1 | 2 | 3 | 4 |
| | 5 | 6 | $7^{M}$ | $8^{M+}$ | 9 | 10 | 11 |
| FEBRUARY | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| | 26 | 27 | 28 | 29 | 1 | 2 | 3 |
| | 4 | 5 | $6^{M}$ | $7^{M+}$ | 8 | 9 | 10 |
| MARCH | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| | 1 | 2 | $3^{M}$ | $4^{M+}$ | 5 | 6 | 7 |
| | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| APRIL | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| | 29 | 30 | 1 | 2 | 3 | 4 | 5 |
| | 6 | 7 | $8^{M}$ | $9^{M+}$ | 10 | 11 | 12 |
| MAY | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| | 27 | 28 | 29 | $\boxed{30}$ | 31 | 1 | 2 |
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| JUNE | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| | 24 | 25 | $26^{+}$ | $27^{M+}$ | $28^{M+}$ | 29 | 30 |
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| | S | M | T | W | T | F | S |
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| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
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| JULY | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| | 22 | 23 | 24 | $25^{M+}$ | $26^{M}$ | 27 | 28 |
| | 29 | 30 | 31 | 1 | 2 | 3 | 4 |
| | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| AUGUST | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| | 19 | 20 | 21 | $22^{M+}$ | $23^{M}$ | 24 | 25 |
| | 26 | 27 | 28 | 29 | 30 | 31 | 1 |
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| SEPTEMBER | 16 | 17 | 18 | $19^{M+}$ | $20^{M}$ | 21 | 22 |
| | 23 | 24 | 25 | 26 | 27 | 28 | 29 |
| | 30 | 1 | 2 | 3 | 4 | 5 | 6 |
| | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| OCTOBER | 14 | 15 | 16 | $17^{M+}$ | $18^{M}$ | 19 | 20 |
| | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| | 28 | 29 | 30 | 31 | 1 | 2 | 3 |
| | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| NOVEMBER | 11 | 12 | 13 | $14^{M+}$ | $15^{M}$ | 16 | 17 |
| | 18 | 19 | 20 | 21 | $\boxed{22}$ | $\boxed{23}$ | 24 |
| | 25 | 26 | 27 | 28 | 29 | 30 | 1 |
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| DECEMBER | 16 | 17 | 18 | $19^{M+}$ | $20^{M}$ | 21 | 22 |
| | 23 | 24 | 25 | 26 | 27 | 28 | 29 |
| | 30 | 31 | 1 | 2 | 3 | 4 | 5 |
| | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1985 JANUARY | 13 | 14 | $15^{+}$ | $16^{M+}$ | $17^{M+}$ | 18 | 19 |
| | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| | 27 | 28 | 29 | 30 | 31 | | |
| | S | M | T | W | T | F | S |

17 Regular World Day (RWD)
18 Priority Regular World Day (PRWD)
15 Quarterly World Day (QWD) also a PRWD and RWD
Regular Geophysical Day (RGD)
$\boxed{6\ 7}$ World Geophysical Interval (WGI)
$17^{+}$ Incoherent Scatter Coordinated Observation Day and Coordinated Tidal Observation Day
$\boxed{30}$ Day of Solar Eclipse
$\boxed{4\ 5}$ Airglow and Aurora Period
$10^{M}$ Dark Moon Geophysical Day (DMGD)

NOTES:
1. Days with unusual meteor shower activity are: Northern Hemisphere Jan. 3, 4; Apr 21, 22; May 3-5; Jun 8-12, 27-29; Jul 27-29; Aug 10-13; Oct 19-22; Nov 2, 3, 17; Dec 12-15, 21, 22, 1984. Southern Hemisphere May 2-5; Jun 8-12, 20, 21; Jul 26-30; Oct 19-22; Nov 2, 3, 17; Dec 5-7, 12-15, 1984.
2. Middle Atmosphere Program (MAP) began 1 Jan 1982 and runs through 1985.

OPERATIONAL EDITION, September 1983

Meetings (cont. on p. 972)

## Meetings (cont. from p. 971)

tional Water Well Association. (NWWA, 500 W. Wilson Bridge Rd., Worthington, OH 43085; tel.: 614-846-9355.)

May 24–26 **Symposium on the History of Soil and Water Conservation**, Columbia, Mo. Sponsors, Missouri Cultural Heritage Center at the Univ. of Missouri, the Agricultural History Society, and the Soil Conservation Service of the U.S. Dept. of Agriculture. (Susan Flader, Dept. of History, Univ. of Missouri, Columbia, MO 65211, tel.: 314-882-2481 or 314-442-1058; or Douglas Helms, Historian, Soil Conservation Service, P.O. Box 2890, Washington, DC 20013, tel.: 202-382-0042.)

May 29–June 2 **12th International Congress on Irrigation and Drainage**, Fort Collins, Colo. Sponsor, U.S. Committee on Irrigation, Drainage, and Flood Control (USCIDFC). (USCIDFC, P.O. Box 15326, Denver, CO 80215.)

May 29–June 1 **Joint Meeting of the 11th Annual Meeting of the Canadian Geophysical Union and the 18th Annual Congress of the Canadian Meteorological and Oceanographic Society**, Halifax, Nova Scotia, Canada. (S. T. Smith or H. R. Jackson, Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, Nova Scotia, Canada B2Y 4A2.)

June 4–7 **Symposium on Climate and Paleoclimate of Lakes, Rivers, and Glaciers**, Igls, Austria. Sponsor, International Commission on Climate, IAMAP. (M. Kuhn, Institut fuer Meteorologie und Geophysik, Schoepfstrasse 41, A-6020 Innsbruck, Austria.)

June 4–8 **IWRA Seminar on River Basin Strategy**, Linköping, Sweden. (U. Lohm, Water Theme, Linköping Univ., S-58183, Linköping, Sweden.)

June 4–8 **Seventh International Conference on Atmospheric Electricity**, Albany, N. Y. Sponsors, IAMAP International Commission on Atmospheric Electricity and AMS. (R. E. Orville, Atmospheric Electricity Conference, E.S. 214, 1400 Washington Ave., SUNY, Albany, NY 12222; tel.: 518-457-3987.)

June 4–8 **Third International Conference on Urban Storm Drainage**, Göteborg, Sweden. Sponsors, IAHR and International Association on Water Pollution Research. (P. Malmqvist, c/o Dept. of Hydraulics, Chalmers Univ. of Technology, S-412 96 Göteborg, Sweden.)

June 6–9 **Second American Conference on Ice Nucleating Bacteria**, Flagstaff, Ariz. (Ralph M. Bilby Research Center, Box 6013, Northern Ariz. Univ., Flagstaff, AZ 86011.)

June 11–13 **Symposium on Critical Assessment of Forecasting in Western Water Resource Management**, Seattle, Wash. Sponsor, American Water Resources Association. (G. R. Minton, President, Resource Planning Assoc., 115 Lynn St., Seattle, WA 98109; tel.: 206-282-1681.)

June 10–15 **65th Annual AAAS Meeting** (Pacific Division), San Francisco. (Alan E. Leviton, Exec. Dir., AAAS (Pacific Division), Calif. Academy of Sciences, Golden Gate Park, San Francisco, CA 94118, tel.: 415-752-1554.)

June 18–22 **Fifth International Conference on Finite Elements in Water Resources**, Burlington, Vt. Sponsors, University of Vermont, AGU. (J. P. Laible, Dept. of Civil Eng. and Mech. Eng., Univ. of Vermont, Burlington, VT 05405; tel.: 802-656-3800.)

June 19–21 **Third International Conference on Marine Simulation**, Rotterdam. Sponsor, Maritime Research Institute Netherlands. (Secretariat MARSIM 84, c/o Maritime Research Institute Netherlands, P.O. Box 1555, 3000 BN Rotterdam, The Netherlands.)

June 23–30 **Penrose Conference on Mélanges of the Appalachian Orogen**, Newfoundland. Sponsor, GSA. (Brenna E. Lorenz, Dept. of Earth Sciences, Memorial Univ. of Newfoundland, St. Johns, Newfoundland A1B 3X5 Canada.)

June 24 **International Conference on Geomembranes**, Denver, Colo. (A. I. Johnson, Woodward-Clyde Consultants, 7600 E. Orchard Road, Englewood, CO 80111; tel.: 303-694-2770.)

June 24 **International Symposium on Impermeable Barriers for Soil and Rock**, Denver, Colo. (A. I. Johnson, Woodward-Clyde Consultants, 7600 E. Orchard Road, Englewood, CO 80111; tel.: 303-694-2770.)

June 24–30 **14th International Conference on Mathematical Geophysics**, Loen, Norway. (L. Tronrud, NTNF/NORSAR, P.O. Box 51, N-2007 Kjeller, Norway; telex: 18147 Lcin.)

June 25–27 **Rock Mechanics in Productivity and Protection**, 25th U.S. Symposium on Rock Mechanics, Evanston, Ill. Sponsor, AGU. (Charles H. Dowding, Dept. of Civil Eng., Northwestern Univ., Evanston, IL 60201; tel.: 312-492-7270.)

June 25–July 7 **ICSU Committee on Space Research 25th Meeting**, Graz, Austria. (Richard C. Hart, Space Science Board, JH-828, National Academy of Sciences, 2101 Constitution Ave., N.W., Washington, DC 20418.)

June 25–July 7 **Symposium on Space Observations for Climate Studies**, Graz, Austria. Sponsor, World Climate Program. (S. Ruttenberg, Secretary, COSPAR Commission A, NCAR, Boulder, CO 80307.)

June 25–28 **Symposium of the Achievements of the International Magnetospheric Study**, Graz, Austria. Sponsor, ICSU Scientific Committee on Solar-Terrestrial Physics. (J. G. Roederer, Geophysical Institute, Univ. of Alaska, Fairbanks, AK 99701.)

June 26–28 **1984 International Conference on Lightning and Static Electricity**, Orlando, Fla. Sponsors, NOAA, IEEE, SAE-AE4 Committee, and several military and civilian air transportation agencies in the U.S. and UK. (J. J. Fisher, Conference Chairman, U.S. Naval Air Systems Command, P.O. Box 15086, Arlington, VA 22215; tel.: 202-692-7822; or O. Odam, European Coordinator, Royal Aircraft Establishment, Farnborough, Hants, GU14 6TD UK; tel.: 0252-24461, ext. 2638.)

June 26–28 **International Symposium on Deep Structure of the Continental Crust: Results from Reflection Seismology**, Ithaca, N.Y. Sponsor, AGU. (Muawia Barazangi, Conference Coordinator, Dept. of Geological Sciences, Cornell Univ., Ithaca, NY 14853; tel.: 607-256-6411 or telex: 937478.)

July 9–18 **International Symposium on Space Techniques for Geodynamics**, Sopron, Hungary. Sponsors, Hungarian Academy of Sciences and IAG/COSPAR Joint Commission on the International Coordination of Space Techniques for Geodesy and Geodynamics. (Chr. Reigber, Deutsches Geodätisches Forschungsinstitut, Abt. I, Marstallplatz 8, D-8000 Munich 22, FRG.)

July 9–13 **Longitude Zero**, Greenwich, UK. Sponsors, International Union for the History and Philosophy of Science and the International Astronomical Union. (Conference Officer, "Longitude Zero" Symposium, National Maritime Museum, Greenwich, London SE10 9NF, UK.)

July 16–25 **Symposium on Wave Breaking, Turbulent Mixing, and Radio Probing of the Ocean Surface**, Sendai, Japan. (O. M. Phillips, Dept. of Earth and Planetary Sciences, Johns Hopkins Univ., Baltimore, MD 21218; tel.: 301-338-7036.)

July 21–28 **Eighth World Conference on Earthquake Engineering**, San Francisco, Calif. Sponsor, Earthquake Engineering Research Institute (EERI), AGU. (J. Penzien, Chair, 8WCEE, EERI, 2620 Telegraph Ave., Berkeley, CA 94704.)

July 23–25 **Summer Computer Simulation Conference**, Boston. Sponsor, Society for Computer Simulation. (W. D. Wade, 1984 SCSC Program Chairman, Wade Engineering P.C., P.O. Box 849, Huntington, NY 11743; tel.: 516-271-6075.)

July 23–26 **11th International Symposium on Urban Hydrology, Hydraulics, and Sediment Control**, Lexington, Ky. Sponsor, Univ. of Kentucky. (E. Haden, Coordinator, Office of Continuing Education/Engineering, 223 Transportation Research Bldg., Univ. of Kentucky, Lexington, KY 40506-0043; tel.: 606-257-3972.)

July 24–26 **Water Rights Specialty Conference**, Flagstaff, Ariz. Sponsors, Ground Water Committee and Surface Water Committee of the ASCE Irrigation and Drainage Division. (Kenneth G. Renard, Southwest Watershed Research Center, 2000 E. Allen Rd., Tucson, AZ 85719; tel.: 602-629-6381.)

July 26–27 **A Joint Workshop of the Committee on Climatic Changes and the Ocean and the Joint Scientific Committee for World Climate Research**, Sendai, Japan. (O. M. Phillips, Dept. Earth and Planetary Sciences, Johns Hopkins Univ., Baltimore, MD 21218; tel.: 301-338-7036.)

July 29–August 4 **Eurogeophysics Assembly**, Louvain-la-Neuve, Belgium. Sponsor, European Geophysical Society. (G. M. Brown, Dept. of Physics, Univ. College of Wales, Aberystwyth, Wales, UK.)

July 31–Aug. 2 **Fourth International Symposium on Stochastic Hydraulics**, Univ. of Illinois, Urbana-Champaign. Sponsors, IAHR and AGU. (Ben C. Yen, Wilson H. Tang, or Glenn E. Stout, Dept. of Civil Eng., Univ. of Illinois, 208 N. Romine St., Urbana, IL 61801; tel.: 217-333-0687 or 333-0536.)

July 31–August 3 **Workshop on Fission Track Dating**, Troy, N. Y. Sponsors, General Electric R&D Lab., SUNY at Albany, and Rensselaer Polytechnic Institute. (Donald S. Miller, Dept. of Geology, Rensselaer Polytechnic Institute, Troy, NY 12181.)

Aug. 4–14 **27th International Geological Congress**, Moscow, USSR. Sponsors, USSR National Committee for Geology, IUGS. (Organizing Committee of the 27th IGC, Institute of the Lithosphere, 22, Staromonetny, Moscow, 109180, USSR.)

Aug. 12–17 **20th Annual AWRA Conference and Symposium**, Washington, D. C. (Arlene Dietz, U.S. Army Corps of Engineers, Institute for Water Resources, Casey Bldg., Fort Belvoir, VA 22060; tel.: 703-355-2368.)

Aug. 13–17 **12th International Laser Radar Conference**, Aix-en-Provence, France. Sponsors, IAMAP and AMS. (G. Megie or J. P. Granier, Service D'Aéronomie du CNRS, 12th International Laser Radar Conference, BP 3, 91370-Verrières le Buisson, France.)

Aug. 21–29 **International Radiation Symposium** '84 (IRS), Perugia, Italy. Sponsor, IAMAP Radiation Commission. (Giorgio Fiocco, Chairman, IRS '84, Dipartimento di Fisica, Città Universitaria, 00185 Rome, Italy; telex: INFNRO 613255.)

Aug. 26–31 **Seventh Australian Geological Convention**, Sydney, Australia. Sponsor, Geological Society of Australia. (Secretary 7 AGC, P.O. Box 383, North Ryde, NSW, Australia 2113.)

Aug. 27–31 **Seventh IAHR Symposium on Ice**, Hamburg, Germany. (J. Schwarz, Ice Engineering GmbH., P.O. Box 600 929, 2000 Hamburg, FRG.)

Sept. 3–7 **Quadrennial Ozone Symposium**, Halkidiki, Greece. Sponsors, IAMAP International Ozone Commission (IOC), Commission of the European Communities, the Academy of Athens, and WMO. (Christos S. Zerefos, Chairman, Local Organizing Committee, Physics Dept., Campus Box 149, Univ. of Thessaloniki, Thessaloniki, Greece. Send copy of information request to C. D. Walshaw, Secretary, IOC, Clarendon Laboratory, Oxford Univ., Parks Road, Oxford OX1 3PU, UK.)

Sept. 10–12 **Oceans 84 Conference and Exhibition**, Washington, D. C. Sponsors, Marine Technology Society and Institute of Electrical and Electronics Engineers/Oceanic Engineering Society. (Oceans 84 Technical Program Committee, 1730 M St. N.W., Suite 412, Washington, DC 20036.)

Sept. 10–14 **International Symposium on Hydromechanical Balances of Fresh Water Systems**, Stockholm/Uppsala, Sweden. Sponsors, Swedish Natural Science Research Council, UNESCO, and IAHS. (M. Falkenmark, Exec. Sec. NFRS, Comm. for Hydrology, Box 6711, S-11385 Stockholm, Sweden.)

Sept. 24–25 **Seminar: Enhanced Biological Removal of Phosphorus From Wastewater**, Paris. Sponsor, International Association on Water Pollution Research and Control. (Michel Florentz, Phosphorus Seminar, Anjou-Recherche, 52, rue d'Anjou, 75384 Paris Cedex 08, France; tel.: 266-91-50; telex: Geneaux 280 332 F.)

Sept. 26–28 **Seventh National Groundwater Quality Symposium**, Las Vegas. Sponsor, National Water Well Association. (NWWA, 500 W. Wilson Bridge Rd., Worthington, OH 43085; tel.: 614-846-9355.)

October 10–13 **New Mexico Geological Society 35th Annual Field Conference**, Taos. (R. Riecker, General Chairman, Los Alamos National Laboratory, Mail Stop D446, Earth and Space Sciences Div., Los Alamos, NM 87545.)

Oct. 17–19 **AIPG** Annual Meeting, Orlando, Fla. (Bobby J. Timmons, General Chairman, Timmons Associates, P.O. Box 50606, Jacksonville, FL 32250; tel.: 904-246-4533.)

Oct. 31–Nov. 7 **Regional Assembly of IASPEI**, Hyderabad, India. (Mohan L. Gupta, Organizing Committee, IASPEI Regional Assembly, National Geophysical Research Institute, Hyderabad-500 007, India; telex: 155–478 NGRI IN; cable: Geophysics.)

Nov. 5–8 GSA Annual Meeting, Reno, Nev. (Jean Latulippe, GSA, P.O. Box 9140, Boulder, CO 80301; tel.: 303-447-2020.)

Dec. 16–21 International **Chemical Congress** of Pacific Basin Societies, Honolulu, Hawaii. Sponsors, ACS, Chemical Institute of Canada, and Chemical Society of Japan. (PAC CHEM '84, Meetings and Divisional Activities Dept., ACS, 1155 16th St., N.W., Washington, DC 20036; tel.: 202-872-4396; PAC CHEM '84, Chemical Institute of Canada, 151 Slater St., Suite 906, Ottawa, Ontario K1P 5H3; tel.: 613-233-5623; PAC CHEM '84, Chemical Society of Japan, 1–5, Kanda-Surugadai, Chiyoda-ku, Tokyo 101; tel.: 03–292–6161.)

# 1985

January 7–12 17th International Congress on **Hydrology of Rocks of Low Permeability**, Tucson, Ariz. Sponsors, International Association of Hydrogeologists, AGU. (E. S. Simpson, Dept. of Hydrology and Water Resources, College of Earth Sciences, Univ. of Arizona, Tucson, AZ 85721.)

March 10–15 American Society of **Photogrammetry and American Congress on Surveying and Mapping National Meeting**, Washington, D. C. (Willard A. Kuncis, 4415 Jensen Pl., Fairfax, VA 22032; tel.: 703-425-8790.)

April 1–4 **European Union of Geosciences Biennial Meeting**, Strasbourg, France. (Organizing Committee, Dept. of Earth Sciences, Univ. of Cambridge, Downing St., Cambridge CB2 3EQ, UK.)

May 27–31 **AGU Spring Meeting**, Baltimore, Md. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

Summer Colloquium on Comparative Study of **Magnetospheric Systems**, France. (Dominique Le Quéau and Bent Moller-Pedersen, DASOP, Observatoire de Meudon, F 92195, Meudon Principal Cedex, France; Telex: 200 590 CNET OBS.)

June 9–15 **IWRA** Fifth World Congress, Brussels, Belgium. (Fifth World Congress On Water Resources, Brussels International Conference Centre, Parc des Expositions, Tentoonstellingspark, B-1020 Brussels, Belgium; tel.: 32–2-478–18–60; telex: 23–643.)

Aug. 5–16 **IAMAP/IAPSO** Joint Assembly, Honolulu, Hawaii. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

Aug. 19–23 **Sixth Gondwana Symposium**, Columbus, Ohio. Sponsor, GSA. (D. Elliot, Ohio State Univ., Institute of Polar Studies, 103 Mendenhall, 125 South Oval Mall, Columbus, OH 43210.)

Sep. 17–21 **AIPG** Annual Meeting, St. Paul, Minn. (Robert E. Prendergast, General Chairman, Geotechnical Engineering Corp., 1925 Oakcrest Ave., Roseville, MN 55113; tel.: 612-636-7744.)

Oct. 14–17 **GSA** Annual Meeting, Boston, Mass. (Jean Latulippe, GSA, P.O. Box 9140, Boulder, CO 80301; tel.: 303-447-2020.)



### EXPLANATIONS

This Calendar continues the series begun for the IGY years 1957-58, and is issued annually to recommend dates for solar and geophysical observation which cannot be carried out continuously. Thus, the amount of observational data in existence tends to be larger on Calendar days. The recommendations on data reduction and especially the flow of data to World Data Centers (WDCs) in many instances emphasize Calendar days. The Calendar is prepared by the International Ursigram and World Days Service (IUWDS) with the advice of spokesmen for the various scientific disciplines. For greater detail concerning explanations or recommendations your attention is called to information published periodically in IAGA News, IUGG Chronicle, URSI Information Bulletin or other scientific journals.

The definitions of the designated days remain as described on previous Calendars. **Universal time (UT)** is the standard time for all world days. **Regular Geophysical Days (RGD)** are each Wednesday. **Regular World Days (RWD)** are three consecutive days each month (always Tuesday, Wednesday and Thursday near the middle of the month). **Priority Regular World Days (PRWD)** are the RWD which fall on Wednesdays. **Quarterly World Days (QWD)** are one day each quarter and are the PRWD which fall in the **World Geophysical Intervals (WGI)**. The WGI are fourteen consecutive days in each season, beginning on Monday of the selected month, and normally shift from year to year. In 1984 the WGI will be February, May, August and November.

The **Solar Eclipses** are: May 30 (annular) beginning in the equatorial Pacific Ocean, crossing Mexico, SE United States, Atlantic Ocean and ending in N. Africa (the partial zone ranges from NW S. America to arctic Canada, Greenland, Scandinavia); November 22-23 (total) beginning in New Guinea, crossing north of New Zealand, and ending west of Chile (the partial zone includes the Philippine Islands, Australia, Indonesia, west Antarctica and the extreme south of S. America).

**Meteor showers** (selected by P.M. Millman, Ottawa) include important visual showers and also unusual showers observable mainly by radio and radar techniques. The dates for Northern Hemisphere meteor showers are: Jan 3, 4; April 21-22; May 2-5; Jun 8-12, 27-29, Jul 27-29; Aug 10-13; Oct 19-22; Nov 2, 3, 17; Dec 12-15, 21, 22, 1984. The dates for Southern Hemisphere meteor showers are: May 2-5, Jun 8-12, 20, 21, Jul 26-30, Oct 19-22, Nov 2, 3, 17; Dec 5-7, 12-15, 1984. Note that the meteor showers that come in the first week of May and the third week in October are of particular interest (fragments of Halley's comet) because of the approach of Halley's comet in 1986.

The occurrence of unusual solar or geophysical conditions is announced or forecast by the IUWDS through various types of geophysical "Alerts" (which are widely distributed by telegram and radio broadcast on a current schedule). Stratospheric warmings (**STRATWARM**) are also designated. The meteorological telecommunications network coordinated by WMO carries these worldwide Alerts once daily soon after 0400 UT. For definitions of Alerts see IUWDS "Synoptic Codes for Solar and Geophysical Data, Third Revised Edition 1973" and its amendments. **Retrospective World Intervals** are selected and announced by MONSEE and elsewhere to provide additional analyzed data for particular events studied in the ICSU Scientific Committee on Solar-Terrestrial Physics (SCOSTEP) programs.

### RECOMMENDED SCIENTIFIC PROGRAMS
### PLANNING EDITION

(The following material was reviewed in 1983 by spokesmen of IAGA, WMO and URSI as suitable for coordinated geophysical programs in 1984.)

**Airglow and Aurora Phenomena.** Airglow and auroral observatories operate with their full capacity around the New Moon periods. However, for progress in understanding the mechanism of inter alia, low latitude aurora, the coordinated use of all available techniques, optical and radio, from the ground and in space is required. Thus, for the airglow and aurora 7-day periods on the Calendar, ionosonde, incoherent scatter, special satellite or balloon observations, etc., are especially encouraged. Periods of approximately two weeks' duration centered on the New Moon are proposed for high resolution of ionospheric, auroral and magnetospheric observations at high latitudes during northern winter.

**Atmospheric Electricity.** Not-continuous measurements and data reduction for continuous measurements of atmospheric electric current density, field, conductivities, space charges, ion number densities, ionosphere potentials, condensation nuclei, etc.; both at ground as well as with radiosondes, aircraft, rockets; should be done with first priority on the RGD each Wednesday, beginning on 4 January 1984 at 1800 UT, 11 January at 0000 UT, 18 January at 0600 UT, 25 January at 1200 UT, etc. (beginning hour shifts six hours each week, but is always on Wednesday). Minimum program is at the same time on PRWD beginning with 18 January at 0000 UT. Data reduction for continuous measurements should be extended, if possible, to cover at least the full RGD including, in addition, at least 6 hours prior to indicated beginning time. Measurements prohibited by bad weather should be done 24 hours later. Results on sferics and ELF are wanted with first priority for the same hours, short-period measurements centered around the minutes 35-50 of the hours indicated. Priority Weeks are the weeks which contain a PRWD; minimum priority weeks are the ones with a QWD. The World Data Centre for Atmospheric Electricity, 7 Karbysheva, Leningrad 194018, USSR, is the collection point for data and information on measurements.

**Geomagnetic Phenomena.** It has always been a leading principle for geomagnetic observatories that operations should be as continuous as possible and the great majority of stations undertake the same program without regard to the Calendar.

Stations equipped for making magnetic observations, but which cannot carry out such observations and reductions on a continuous schedule are encouraged to carry out such work at least on RWD (and during times of **MAGSTORM Alert**).

**Ionospheric Phenomena.** Special attention is continuing on particular events which cannot be forecast in advance with reasonable certainty. These will be identified by Retrospective World Intervals. The importance of obtaining full observational coverage is therefore stressed even if it is possible to analyze the detailed data only for the chosen events. In the case of vertical incidence sounding, the need to obtain quarter-hourly ionograms at as many stations as possible is particularly stressed and takes priority over recommendation (a) below when both are not practical.

For the vertical incidence (VI) sounding program, the summary recommendations are: (a) all stations should make soundings at least every quarter hour. Stations which normally record at every quarter should, if possible, record more frequently on **RWDs, particularly at high latitudes;** (b) all stations are encouraged to make f-plots on **RWDs**; f-plots should be made for high latitude stations, and for so-called "representative" stations at lower latitudes for all days (i.e., including **RWDs** and **WGIs**) (Continuous records of ionospheric parameters are acceptable in place of f-plots at temperate and low latitude stations); (c) copies of hourly ionograms with appropriate scales for **QWDs** are to be sent to WDCs; (d) stations in the eclipse zone and its conjugate area should take continuous observations on solar eclipse days and special observations on adjacent days. See also recommendations under **Airglow and Aurora Phenomena.**

For incoherent scatter observation program, every effort should be made to obtain measurements at least on the **Incoherent Scatter Coordinated Observation Days**, and intensive series should be attempted whenever possible in WGIs or the **Airglow and Aurora Periods**. Give Apr 4, Jul 25 and Dec 19 lower priority if you must compensate for the extended 3-day periods in Jan, Jun 1984, and Jan 1985. The need for collateral VI observations with not more than quarter-hourly spacing at least during all observation periods is stressed. Dr. M.J. Baron (USA), URSI Working Group G.5, is coordinating special programs.

For the ionospheric drift or wind measurement by the various radio techniques, observations are recommended to be concentrated on the weeks including **RWDs**.

For traveling ionosphere disturbances propose special periods for coordinated measurements of gravity waves induced by magnetospheric activity, probably on selected **PRWD** and **RWD**.

For the ionospheric absorption program half-hourly observations are made at least on all RWDs and half-hourly tabulations sent to WDCs. Observations should be continuous on solar eclipse days for stations in eclipse zone and in its conjugate area. Special efforts should be made to obtain daily absorption measurements at temperate latitude stations during the period of Absorption Winter Anomaly, particularly on days of abnormally high or abnormally low absorption (approximately October-March, Northern Hemisphere: April-September, Southern Hemisphere).

For back-scatter and forward scatter programs, observations should be made and analyzed on all **RWDs** at least.

For synoptic observations of mesospheric (D region) electron densities, several groups have agreed on using the **RGD** for the hours around noon.

For ELF noise measurements involving the earth-ionosphere cavity resonances any special effort should be concentrated during the **WGIs**.

It is recommended that more intensive observations in all programs be considered on days of **unusual meteor activity.**

**Meteorology.** Particular efforts should be made to carry out an intensified program on the **RGD** -- each Wednesday, UT. A desirable goal would be the scheduling of meteorological rocket sondes, ozone sondes and radiometer sondes on those days, together with maximum-altitude rawinsonde ascents at both 0000 and 1200 UT.

During **WGI** and **STRATWARM** Alert intervals, intensified programs are also desirable, preferably by the implementation of RGD-type programs (see above) on Mondays and Fridays, as well as on Wednesdays.

**Middle Atmosphere Program (MAP).** MAP runs from 1 January 1982 through 1985. Techniques for observing the middle atmosphere should concentrate or center their observations on the RGDs, PRWDs, and QWDs. It is recommended that observing runs for studies of planetary waves and tides be at least 10 days centered on the PRWDs and QWDs. Non-continuous studies of stratospheric warmings and the effects of geomagnetic activity on the middle atmosphere must be initiated by STRATWARM and MAGSTORM alerts, respectively. For more detail see the "Recommended Scientific Programs" on the reverse of the **Middle Atmosphere Dynamics Calendar for 1984**, which will be published as a special edition of the IGC for 1984.

**Solar Phenomena.** Observatories making specialized studies of solar phenomena, particularly using new or complex techniques, such that continuous observation or reporting is impractical, are requested to make special efforts to provide to WDCs data for **Solar eclipse** days, **RWDs** and during **PROTON/FLARE ALERTS.** The attention of those recording solar noise spectra, solar magnetic fields and doing specialized optical studies is particularly drawn to this recommendation.

**Space Research, Interplanetary Phenomena, Cosmic Rays, Aeronomy.** Experimenters should take into account that observational effort in other disciplines tends to be intensified on the days marked on the Calendar, and schedule balloon and rocket experiments accordingly if there are no other geophysical reasons for choice. In particular it is desirable to make rocket measurements of ionospheric characteristics on the same day at as many locations as possible; where feasible, experimenters should endeavor to launch rockets to monitor at least normal conditions on the **Quarterly World Days (QWD)** or on **RWDs**, since these are also days when there will be maximum support from ground observations. Also, special efforts should be made to assure recording of telemetry on **QWD** and **Airglow and Aurora Periods** of experiments on satellites and of experiments on spacecraft in orbit around the sun.

For URSI/IAGA Coordinated Tidal Observations Program (CTOP) contact Dr. R.G. Roper (USA) for the 1984 Calendar.

**The International Ursigram and World Days Service (IUWDS)** is a permanent scientific service of the International Union of Radio Science (URSI), with the participation of the International Astronomical Union and the International Union Geodesy and Geophysics. IUWDS adheres to the Federation of Astronomical and Geophysical Services (FAGS) of the International Council of Scientific Unions (ICSU). The IUWDS coordinates the international aspects of the world days program and rapid data interchange.

This Calendar for 1984 has been drawn up by H.E. Coffey, of the IUWDS Steering Committee, in close association with A.H. Shapley, member of MONSEE of SCOSTEP, and spokesmen for the various scientific disciplines in SCOSTEP, IAGA and URSI. Similar Calendars have been issued annually beginning with the IGY, 1957-58, and have been published in various widely available scientific publications.

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# GAP



## Aeronomy

0430 Composition (Atomic or Molecular)
AN ASSESSMENT OF POSSIBLE OZONE-SOLAR CYCLE RELATIONSHIP INFERRED FROM NIMBUS-4 BUV DATA
Subhil Chandra (NASA/Goddard Space Flight Center, Code 964, Greenbelt, Maryland 20771)

The total ozone and the ozone mixing ratio at various pressure levels in the stratosphere measured from the Nimbus-4 BUV experiment over a seven-year period (1970-1977) comprise a comprehensive data base available to study the possible effects of solar variability on stratospheric ozone. It is shown that with the decrease in solar activity from 1970-1976, the globally averaged ozone inferred from Nimbus-4 data decreases from about 10-12% in the upper stratosphere to about 1-3% in the lower stratosphere. This systematic decrease at all pressure levels is modulated by a quasi-periodic oscillation of about a two-year period. Both the systematic decrease and the quasi-periodic oscillations in ozone seem to be correlated with the conventional indices of solar activity suggesting a solar uv-ozone relationship. Despite this apparent correlation, it is difficult to account for the observed changes at various pressure levels with our current understanding of the photochemical models and the solar uv flux variations over a solar cycle. The agreement between the observed and the calculated profiles of ozone mixing ratio is considerably improved if the BUV data is corrected for the changes in the instrument sensitivity using Umkehr observations as a reference.

J. Geophys. Res., Atmos., Paper 3D1797

## Electromagnetics

0780 Scattering (Numerical Techniques)
SCATTERING BY IMPERFECTLY CONDUCTING AND IMPEDANCE SPHEROIDS: A NUMERICAL APPROACH
A. A. Sebak and L. Shafai (Department of Electrical Engineering, University of Manitoba, Winnipeg, Manitoba, Canada, R3T 2N2)

An approximate numerical method for treating the [illegible]

Rad. Sci., Paper 3S1636

6785 Tropospheric Propagation (Earth Space Depolarization)
COMPARISON OF MEASURED CROSSPOLARIZATION ISOLATION AND PREDICTION FOR RAIN AND ICE ON A 19 GHz SPACE EARTH PATH
D. C. Cox and H. W. Arnold, (Bell Laboratories, Crawford Hill Laboratory, Holmdel, NJ 07733)

[illegible]

Rad. Sci., Paper 3S1818

## Exploration Geophysics

0920 Magnetic and Electrical Methods
INVERSION OF OCEAN BOTTOM MAGNETOTELLURIC DATA REVISITED
D.W. Oldenburg and K.P. Whittall (Dept. of Geophysics and Astronomy, University of British Columbia, Vancouver, B.C., Canada, V6T 1W5), R.L. Parker (Scripps Institution of Oceanography, University of California, San Diego, La Jolla, California, 92093.)

Three ocean bottom magnetotelluric data sets from sites on the Pacific plate are reinterpreted. The initial analysis found a correlation between the lithospheric age and the depth to a conductive zone beneath each site. That work also suggested that the resistivity increased below the conductor. This analysis, which includes new methods for constructing one-dimensional conductivity models, shows that the postulated increase in resistivity is not demanded by the data. It also reveals an unexpectedly large nonuniqueness inherent in the interpretation of those data. The previously reported trends with lithospheric age still exist, but they are not as strong as initially believed. Finally, it is shown rigorously that the different age sites are distinct in that no one-dimensional model can account for all three data sets.

J. Geophys. Res., Earth, Paper 3B1806

## Geodesy and Gravity

1910 Crustal Movements
COMMENT ON "THE IMPACT OF REFRACTION CORRECTION ON LEVELING INTERPRETATIONS IN SOUTHERN CALIFORNIA" BY WILLIAM E. STRANGE
Ross S. Stein (U.S. Geological Survey, MS 77, Menlo Park, CA 94025)

In a recent investigation of southern California leveling data, Strange [1981] doubled the correction previously used by the National Geodetic Survey for atmospheric refraction error. Using data corrected in this manner, Strange [1981] argued that "Uplift at Palmdale and Cajon relative to Los Angeles (BM V32) during 1953-1978 is no greater than 10 cm", and that "The bulk of the motion occurs as localized motion on the San Gabriel Fault during 1953-1964". Neither of these statements from Strange's abstract find support in the refraction-corrected elevations presented in his paper. Strange failed to consistently link elevation changes to his Los Angeles reference station, combined corrected and uncorrected data, and mistakenly rejected two surveys. Using only Strange's refraction-corrected elevations and his reference station (the 1953 height of BM V32 at Los Angeles) I find that 130 ± 19 mm of uplift developed both north and south of the San Andreas Fault between 1965 and 1971. The most critical survey discarded by Strange shows 40 mm of elevation change over a distance of 5 km. Strange contended that the elevation change was caused by a 1966 "leveling blunder" between two bench marks. In fact, the tilt developed uniformly between four bench marks, making blunder untenable. Restoring this survey yields 150 ± 19 mm uplift by 1968 at Grapevine, which lies 10 km south of the 1952 $M_L$=7.2 Kern County epicenter and north of both the San Gabriel and San Andreas Faults. These results contradict Strange's assertions as to the magnitude, location, and period of uplift. (aseismic uplift, geodetic measurement, leveling refraction, Palmdale)

J. Geophys. Res., Earth, Paper 3B0187

1930 High-order harmonics of the gravity potential field and local gravity anomalies
A COMPARISON OF SATELLITE DOPPLER AND GRAVIMETRIC GEOID UNDULATIONS CONSIDERING TERRAIN CORRECTED GRAVITY DATA
R.H. Rapp (Department of Geodetic Science and Surveying, 1958 Neil Avenue, Columbus, Ohio 43210), C. [illegible]

[illegible]

J. Geophys. Res., Earth, Paper 3B1794

1935 Low-order harmonics of the gravity potential field
POSTGLACIAL REBOUND OBSERVED BY LAGEOS AND THE EFFECTIVE VISCOSITY OF THE LOWER MANTLE
D. P. Rubincam (Geodynamics Branch, Code 921, NASA Goddard Space Flight Center, Greenbelt, MD 20771)

[illegible] the effective viscosity may have permitted several degrees of polar wander due to glaciation during the Quaternary Ice Age.

J. Geophys. Res., Earth, Paper 3B1807

## Geomagnetism and Paleomagnetism

2599 General (Structural Variations)
POST-12 MILLION YEAR CLOCKWISE ROTATION IN THE CENTRAL COLUMBIA PLATEAU, WASHINGTON
S. P. Reidel (Rockwell International, Richland, Washington, 99352), J. R. Scott, R. P. Pozarsi, R. W. Cross, and R. Dick

The Lomona flow (12 mybp) of the Columbia River Basalt Group was sampled for paleomagnetic analysis at 37 sites in the Yakima Fold Belt of the central Columbia Plateau to assess the pattern of deformation. Field directions from anticlinal ridges are found to be rotated clockwise relative to sites from synclinal areas. Two geographic patterns of rotation are present. The primary pattern is one in which the greatest amount of rotation occurs in the crest-hinge area of the anticlines and decreases into synclines. A secondary pattern in which the amount of rotation is consistent within a geometric segment but varies among them, is superimposed on the primary pattern. The pattern of clockwise rotation is interpreted to be the result of local tectonic rotation occurring along a closely spaced north-northwest trending primary shear system and northeast-trending secondary shear system. The shear system and concurrent rotation are interpreted to have developed during the growth of the Yakima folds. The relationship between the paleomagnetic data and the geologic structures can be used to constrain tectonic models for the Columbia Plateau. The data reported in this study indicate that clockwise rotation can not be attributed to rigid block or microplate rotation, but support models that predict localized dextral shear. Furthermore, it is postulated that this mechanism may, in part, contribute to clockwise rotation observed in other parts of the Western United States. (C) Yakima Rotation, Yakima Fold Belt).

Tectonics, Paper 3T1835

## Oceanology
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2599 Geomagnetism and Paleomagnetism (General)
PALEOMAGNETIC RESULTS FROM THE CENTRAL SIERRA NEVADA: CONSTRAINTS ON RECONSTRUCTIONS OF THE WESTERN UNITED STATES
Leah E. Frei (Dept. of Geophysics, Stanford University, Stanford, CA 94305), James R. Magill and Allan Cox
Paleomagnetic results from three plutons of the central Sierra Nevada limit the motion of the Sierra Nevada relative to the North American craton to 5°±8° of poleward motion and 7°±11° of clockwise rotation since about 90 Ma. The indicated rotation and translation are not significant at the 95% confidence level. A new tectonic model is presented that is consistent with all available paleomagnetic data from the Sierra Nevada, Great Valley, Klamaths, Oregon Coast Range, Cascades and western Nevada. The paleogeographic reconstructions of this model associate the displacement of major crustal blocks with Basin and Range extension starting at about 30 Ma. This model accounts for about 15° of clockwise rotation of the Klamaths and southern Cascades, about 2° of clockwise rotation of the Sierra Nevada and Great Valley, and 26° of clockwise rotation of the Oregon Coast Range since 30 Ma. The model is consistent with 40° of clockwise rotation of the Oregon Coast Range before 30 Ma, as proposed by Magill and Cox [1980]. The amount of Basin and Range extension in this model at latitude 41°N is 225 km directed E-W and at latitude 35°N is 245 km directed WSW-ENE.
Tectonics, Paper 3T1890

2599 Geomagnetism and Paleomagnetism
PALEOMAGNETIC EVIDENCE FOR SPATIALLY DISTRIBUTED POST-MIOCENE ROTATION OF WESTERN WASHINGTON AND OREGON, U.S.A.
Steven D. Sheriff (Department of Geology, University of Montana, Missoula, Montana, 59812)
Anomalous paleomagnetic directions have been determined for 17 sites in the Frenchmans Springs Member of the Wanapum Basalt Formation, Columbia River Basalt Group. These sites are located in the Ginkgo Flows from near Vantage, Washington, to Portland, Oregon, a distance of approximately 300 km. The average paleomagnetic direction for six of these sites, centered around Vantage is D = 147°, I = 41°, $\alpha_{95}$ = 4.5. The expected Miocene field direction is D = 355°, I = 65°. At some localities there exists two distinct Ginkgo Flows, in direct stratigraphic succession, with statistically identical anomalous directions. Their anomalous paleomagnetic direction makes these flows a valuable marker horizon in the Columbia River Basalt Group. The non-dipole field direction of the Ginkgo flows correlates well with available results from the Miocene Cape Foulweather Basalts of Oregon. This correlation strongly supports the hypothesis that those coastal basalts of Oregon are the distal ends of Columbia Plateau derived basalt flows. The spatial distribution of these anomalous field directions suggests about 14 of clockwise rotation between Vantage and Portland. Combining these data with data from the Oregon Coast basalts allows a maximum declination difference of about 35. The increase in declination can be best explained by clockwise rotation, about nearby vertical axes, increasing to the southwest across the Columbia Plateau and Oregon coast.
Tectonics, Paper 3T1891

## Hydrology

3160 Runoff and Streamflow
MODELING RAPIDLY VARIED FLOW IN TAILWATERS
Michael G. Ferrick (USA Cold Regions Research and Engineering Laboratory, Hanover, NH, 03755), Jonathan Bilmes and Sam E. Long
Peak power generation with hydropower creates flow conditions in tailwater rivers characterized by high and low flows and abrupt transitions. An understanding of the downstream propagation of the sharp-fronted, large-amplitude waves of relatively short period that are created is important for describing rapidly varying flows in tailwaters of hydroelectric plants and following the breach of a dam. We developed a numerical model of these waves by first identifying the primary physical processes and then performing an analysis of the solution technique. A linear analysis of the dynamic open channel flow equations provides relationships describing flow wave attenuation, diffusion and dispersion in rivers. A one-dimensional diffusion wave model modified for application to tailwaters, simulates the important physical processes, and is straightforward to apply. The "modified equation" and von Neumann analyses provide insight into the effects of numerical parameters θ, Δx and Δt upon stability and dissipative and dispersive behavior of the solution, but the Hirt analysis is found to yield incorrect phase relationships. The capability and accuracy of the model are enhanced when physical diffusion of a river wave is balanced by numerical diffusion in the model. Maintaining the diffusion balance requires that the parameter θ be variable and in some instances negative. Field studies were conducted in two greatly different tailwaters to assess our understanding of large-scale, rapidly varying flow waves. The accurate simulation of waves having wide ranging amplitudes, shapes, periods and mean flows attests to the soundness of both the physical basis of the model and the numerical solution technique. These studies reveal that diffusion of short-period waves in natural, free-flowing rivers is significant, and that inertia is negligible. (River flow waves, hydropower peaking, diffusion wave model).
Water Resour. Res., Paper 3W1757

3180 Water Quality
ACID MINE DRAINAGE FROM RECLAIMED COAL-STRIPMINES: II. SIMULATION RESULTS OF MODEL
D. B. Jaynes (USDA/ARS, U. S. Water Conservation Laboratory, 4331 East Broadway, Phoenix, AZ 85040), B. S. Pionke, and A. S. Rogowski
Acid mine drainage from reclaimed coal-stripmines is simulated by use of a comprehensive model described in an earlier paper. The simulated concentrations of key components are well within the ranges of measured values from reclaimed mines. In systems without iron-oxidizing bacteria, the simulations indicate that oxygen is the only important oxidizer of pyrite. The typical physical parameters used here, the diffusion rate of oxygen is the primary factor controlling the rate of pyrite oxidation. The pyrite oxidation rate is decreased by decreased air-filled porosity, increased tortuosity of the oxygen diffusion path, increased size of the spoil fragments, and by burying the pyritic material at deeper depths. Where oxygen resupply is not limiting, the results indicate that iron-oxidizing bacteria can greatly increase the rate of pyrite oxidation. Whether or not bacteria are important in these mines depends primarily on the pH of the spoil solution. In the optimal pH range, between reduced bacterial efficiency and reduced ferric iron solubility (2.0 < pH < 3.0), the pyrite oxidation rate is accelerated by bacterially produced ferric iron. The extent and type of chemical reactions between [illegible] produced by pyrite oxidation, and the spoil matrix, appears to be crucial in establishing the pH of the spoil solution. (Pyrite, stripmines, Thiobacillus ferrooxidans, modeling).
Water Resour. Res., Paper 3W1774

## Meteorology

3710 Boundary Layer Structures and Processes
SEA-BREEZE-LIKE WINDS ACROSS THE NORTH WALL OF THE GULF STREAM: AN ANALYTICAL MODEL
S. A. Hsu (Coastal Studies Institute, Louisiana State University, Baton Rouge, Louisiana 70803)
Sea-breeze-like winds have been observed on the warmer side of the Gulf Stream when synoptic-scale winds blow from cool shelf water toward a warm water surface (Hsu et al., 1981). It is shown that a simple, thermally driven analytical model can explain satisfactorily the increase in wind speed from the cold to the warmer water side as resulting from horizontal temperature gradient across the Gulf Stream.
J. Geophys. Res., Oceans, Paper 3C1888 11/30

3740 Instruments (Ozone Sonde)
THE FREQUENCY RESPONSE OF AN ELECTROCHEMICAL OZONE SONDE AND ITS APPLICATION TO THE DECONVOLUTION OF OZONE PROFILES
D. De Muer, H. Malcorps (Koninklijk Meteorologisch Instituut, Ringlaan, 3, 1180 Brussels, Belgium)
The frequency response of the combined sensor and air sampling system of an electrochemical ozone sonde has been determined by means of a digital Fourier analysis. The measured frequency response can be represented by a first order process and a diffusion process in series. If the mean ozone concentration at the input is below a certain level, a fraction of the ozone passes through an additional diffusion process. The variation of the frequency response as a function of the solution temperature and the background ozone level was determined for the ranges of interest. A satisfactory physical interpretation for the behaviour of the frequency response is given. If the frequency response of the sensor is known, the ozone soundings may be corrected for it by deconvolution; this results in a highly improved correspondence between ascent and descent profiles. (Frequency response, deconvolution of ozone profiles).
J. Geophys. Res., Atmos., Paper 3D1829

3799 General
RADIATIVE HEATING RATES NEAR THE STRATOSPHERIC FOUNTAIN
G. Mark Doherty, Reginald E. Newell (54-1522, Department of Earth, Atmospheric and Planetary Sciences, M.I.T., Cambridge, Massachusetts, 02139) and Edwin F. Danielsen
Radiative heating rates are computed for various sets of conditions thought to be appropriate to the stratospheric fountain region: with and without a layer of cirrus cloud between 100 and 150 mb; with standard ozone and with decreased ozone in the lower stratosphere, again with and without the cirrus cloud; and with different temperatures in the tropopause region. The presence of the cloud decreased the radiative cooling above it in the lower stratosphere. The cloud is heated at the base and cooled at the top and thus radiatively destabilized; overall it gains energy by radiation. Decreasing ozone above the cloud also tends to cool the lower stratosphere. The net effect is a tendency for vertical convergence and horizontal divergence in the cloud region. High resolution profiles of temperature, ozone and cloudiness within the fountain region are required in order to assess the final balance of the various processes.
J. Geophys. Res., Atmos., Paper 3D1810 11/29

## Mineralogy, Petrology, and Crystal Chemistry

4260 Paragenesis, petrography, and petrogenesis
ORIGIN OF SPINEL-RICH CHONDRULES AND INCLUSIONS IN CARBONACEOUS AND ORDINARY CHONDRITES
A. S. Kornacki (Smithsonian Astrophysical Observatory, Cambridge, Massachusetts, 02138) and B. Fegley, Jr.
Our evaluation of three models of the origin of spinel-rich chondrules and inclusions includes new calculations of the major-element refractory mineral condensation sequence from a gas of solar composition over a wide pressure interval. Our condensation calculations show that spinel-rich chondrules did not crystallize from metastable liquid condensates, and that spinel-rich inclusions are not aggregates of refractory nebular condensates. We propose that spinel-rich objects are fractionated distillation residues of small aggregates of primitive dust that lost Ca,Si-rich partial melts by evaporation, ablation, or splashing during collisions. This model also explains why spinel-rich chondrules and inclusions: (1) are usually smaller than melilite-rich chondrules and inclusions; (2) often have highly fractionated trace-element compositions; and (3) usually do not contain Pt-metal nuggets even when they are more enriched in the Pt-group metals than nugget-bearing melilite-rich objects. (Ca,Al-rich inclusions, condensation, hibonite, spinel chondrules).
J. Geophys. Res., Earth, Paper 3B5047

4270 Properties of minerals
WÜSTITE ($Fe_{1-x}O$): A REVIEW OF ITS DEFECT STRUCTURE AND PROPERTIES
Robert M. Hazen (Geophysical Laboratory, Carnegie Institution of Washington, Washington, D.C., 20008) and Raymond Jeanloz
Wüstite is a complex nonstoichiometric oxide of iron with the general structural formula

$$^{VI}[Fe^{2+}_{1-3x}Fe^{3+}_{2x}\square_{x}]^{IV}Fe^{3+}_{t}O$$

where 0.04 < x < 0.12 and 0 < t < x ≤ 4.5. Wüstites of a given bulk composition exist in a variety of structure types characterized by differing ratios of octahedral to tetrahedral ferric iron and by differing degrees of long- and short-range order of clustered defects. In addition, most, if not all, wüstites have resolved magnetite or iron lamellae on the scale of several tens of unit cells. Though wüstite is compositionally intermediate between pure FeO and magnetite, wüstite is not structurally intermediate and thus does not represent a solid solution between the two stoichiometric iron oxides. Physical properties of wüstite, including cation diffusion, electrical conductivity, and magnetic properties, are dependent on defect structure type and composition, as well as degree of stoichiometry. Simple linear relationships between stoichiometry and molar volume or between stoichiometry and bulk modulus, for example, do not obtain. Experimental studies on wüstite should include data on conditions of synthesis, as well as details on the structural state before and after the experiments. (Wüstite, defect structures, nonstoichiometry, iron oxide, bulk modulus).
Rev. Geophys. Space Phys., Paper 3R1715

## Oceanography

4760 Sea Ice
SEA ICE STRUCTURE AND BIOLOGICAL ACTIVITY IN THE ANTARCTIC MARGINAL ICE ZONE
D. K. Clarke, S. F. Ackley (U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, N.H. 03755)
Ice cores obtained during October-November 1981 from Weddell Sea pack ice were analyzed for physical, chemical and biological parameters. Frazil ice which is associated with dynamic, turbulent conditions in the water column predominated (70%). Both floe thickness and salinity indicate ice which is less than one year old. Chemical analyses, particularly with regard to the nutrients, revealed a complex picture. Phosphate values are scattered relative to the dilution curve. Nitrate and silicate values are lower than expected from simple mixing with salinity and suggest dilution upon melting the ice. Nitrite values are higher in the ice than in adjacent waters. Frazil ice formation which probably concentrates algal cells from the water column into ice floes results in higher initial [illegible] concentrations in the ice than in adjacent waters. This mechanical concentration is further enhanced by subsequent reproduction within the ice. Ice core chlorophyll ranged from 0.09 to 3.0 mg/m², comparable to values previously reported for this area but significantly lower than values for Antarctic coastal fast ice. The dominance of frazil ice in the Weddell is one of the major differences between this area and others. Consequently we believe that ice structural conditions significantly influence the biological communities in the ice.
J. Geophys. Res., Oceans, Paper 3C1744

4770 Turbulence
SHEETLIKE PLUMES NEAR A HEATED BOTTOM PLATE AT LARGE RAYLEIGH NUMBER
N. Tamai (Department of Civil Engineering, University of Tokyo, Hongo 7-3-1, Bunkyo-ku, Tokyo, Japan, 113), T. Asaeda
Fundamental mechanisms of sheetlike plumes generated on a heated bottom plate have been studied experimentally. The range of the flux Rayleigh number was between $10^8$ and $10^{11}$. The Prandtl number was between 6.0 and 6.7. The values of aspect ratio were 3 to 10. A plan of sheetlike plumes adjacent to the bottom plate takes a polygonal pattern, and these sheetlike plumes are named Bursting Lines in this paper. The average length of the side of these bursting lines is expressed as a sole function of flux Rayleigh number and the length is nondimensionalized by fluid depth. It is confirmed that sheetlike plumes consist of a set of thermals that are repeatedly discharged along bursting lines and that intermittency exists in thermal activity from a microscopic point of view. It is also shown that the nondimensional frequency of the production of thermals is proportional to $Ra_F$ and the characteristic duration is inversely proportional to the square root of $Ra_F$. The occurrence of intervals of thermals in the initial stage with the growth of the quasi-steady convective motion infers that the mechanism of the generation of thermals remains unchanged under the influence of global circulation. (Large Rayleigh number, sheetlike plumes, bursting phenomena).
J. Geophys. Res., Oceans, Paper 3C1[illegible]

4799 General
CONVECTIVE TRANSPORT OF BRINE AND THAW OF SUBSEA PERMAFROST: RESULTS OF NUMERICAL SIMULATIONS
D. W. Swift (Geophysical Institute, University of Alaska, Fairbanks, Alaska, 99701) and William D. Harrison
A two-dimensional numerical simulation is used to investigate the circulation of brine in the thawed porous bottom sediments which overly ice-bearing permafrost on the continental shelf of the Arctic Ocean. The brine motion is assumed to be governed by Darcy's Law and is effective in transporting salt to the ice-bearing sediments and therefore effective in determining their thaw rate. The simulations are initiated by assuming that the initial brine concentration in the thawed sediments match the average annual salinity of the overlying sea water. A diffusive layer along the phase boundary develops at the base of the thawed sediments and thickens to the point where it becomes convectively unstable. The system is followed in time to observe the development of a stable convective flow pattern. Simulations were run at Rayleigh numbers of 1750 and 17,500. In the 1750 Rayleigh number run the boundary layer and convective plumes had characteristic thicknesses of about two meters in a 20 m thick thaw layer. The high Rayleigh number run had thicknesses of only a few tenths of a meter. The high Rayleigh number run is more consistent with the observations, but the results are at sufficient variance with the observations to suggest there is some not yet identified process affecting the transport of brine to the phase boundary. (Subsea permafrost, brine convection, Arctic continental shelf).
J. Geophys. Res., Oceans, Paper 3C1809

## Particles and Fields—Ionosphere

5535 Interactions between waves and particles
ELECTROSTATIC HYDROGEN-CYCLOTRON WAVE EMISSION BELOW THE HYDROGEN-CYCLOTRON FREQUENCY IN THE AURORAL ACCELERATION REGION
N. Singh (Center for Atmospheric and Space Sciences, Utah State University, Logan, Utah 84322), R. W. Schunk and J. R. Conrad
A mechanism is suggested for the excitation of electrostatic ion-cyclotron waves at frequencies below the ion-cyclotron frequency in the midst of the auroral acceleration region, which is assumed to consist of downward moving double layers. The mechanism involves upward flowing ions interacting with a downward flowing background plasma. The upward flowing ions are the ion beams accelerated by the double layer. The downward motion of the background plasma corresponds to a plasma expansion into the density cavity that develops in connection with double layer formation in the acceleration region. The ion-cyclotron waves excited by the counterstreaming flows are doppler shifted to frequencies below the harmonics of the ion cyclotron frequency. It is suggested that such wave emissions could account for some very narrow-banded waves at frequencies below the hydrogen cyclotron frequency that were observed by the S3-3 satellite.
J. Geophys. Res., Space, Paper 3A1841

5599 General (Ionosphere Modification)
THE HF-INDUCED PLASMA LINE BELOW THRESHOLD
J. A. Fejer (Arecibo Observatory, P. O. Box 995 Arecibo, Puerto Rico 00613) and M. Sulzer
Observations at Arecibo of the HF-induced plasma line for low powers of the HF modifying transmitter are described and interpreted. The observed spectra were centered on the radar frequency minus the HF modifying frequency, and had the same shape and width as the ion line of incoherent backscatter. The importance of the standing-wave nature of the HF pump wave for such observations is stressed. (Ionospheric modifications, plasma line spectra below threshold).
Rad. Sci., Paper 3S1835







## Particles and Fields—Magnetosphere

5736 (Magnetic tail)
EVIDENCE FOR PARTICLE ACCELERATION PROCESSES IN THE MAGNETOTAIL
E. Kirsch (Max-Planck-Institut für Aeronomie, D-3411 Katlenburg-Lindau, W.-Germany), G.P. Pavlos and E.T. Sarris
Measurements of energetic protons (E >50 keV), electrons (E >30 keV), α-particles (E ~0.64 MeV) and Z ≥2-particles (E >2 MeV) in the distant magnetotail by the Energetic Particle Experiment (NOAA, Boulder) and the JHU/APL Proton-Electron Telescope on board the IMP-8 satellite for the period November 23-26, 1973 are used to investigate the particle acceleration process in the magnetotail. Evidence is presented that the plasma heating process starts 20-30 min before the energetic particle bursts, which suggests that most probably the particle energization in this event takes place in two different phases: a) up to E ~50 keV in association with the plasma heating process and b) explosive acceleration in excess of E ≳1 MeV energy. (Particle acceleration, magnetotail).
J. Geophys. Res., Space, Paper 3A1745

5739 Magnetopause
MAGNETOPAUSE STRUCTURE AND THE QUESTION OF PARTICLE ACCESSIBILITY
Elden C. Whipple, Jay R. Hill and J. David Nichols, (Center for Astrophysics and Space Sciences, University of California, San Diego, La Jolla, California, 92093)
Previous Vlasov theories of the plane magnetopause have yielded non-unique solutions because particle distribution functions were assigned arbitrarily in different regions of phase space. We show that consideration of particle accessibility removes this non-uniqueness. In a restricted model consisting of a collisionless, steady-state, plane model with no normal magnetic field component, particles are trapped at the magnetopause. Therefore these restrictions must be relaxed in order to allow for particle access to the magnetopause via drifts from source regions. The first adiabatic invariant for particle motion can be defined in such a way that it is preserved in regions of large field gradients, provided that the gradients are in a direction primarily perpendicular to the particle drifts. This generalized invariant provides an adiabatically conserved quantity which can be used to characterize particles as they move from a source region, through the drift region, and into the magnetopause itself. We show how to resolve the accessibility question. We show how to obtain magnetopause structure based on location of the particle guiding points, and give some preliminary results. However, a complete solution will probably require a time-dependent determination of the particle drift paths. (Magnetopause, adiabatic invariants).
J. Geophys. Res., Space, Paper 3A1792

5755 Plasma Instabilities
ELECTRON-CYCLOTRON MASER EMISSION: RELATIVE GROWTH AND DAMPING RATES FOR DIFFERENT MODES AND HARMONICS
D. B. Melrose (School of Physics, University of Sydney, Sydney, NSW, 2006, Australia), R. G. Hewitt* (Department of Astro-Geophysics, University of Colorado, Boulder, Colorado, 80309) and G. A. Dulk* (Division of Radiophysics, CSIRO, P.O. Box 76, Epping, NSW, 2121, Australia)
The growth rates for cyclotron maser emission of the x, o and z modes at the lowest harmonics are compared for a loss cone distribution. The dominant mode is the fundamental x mode (for $\omega_p/\Omega_e \lesssim 0.3$), the z mode (or perhaps the fundamental o mode) for $0.3 \lesssim \omega_p/\Omega_e \lesssim 1.0$, and the o mode (or perhaps the second harmonic x mode) for $1.0 \lesssim \omega_p/\Omega_e \lesssim 1.4$. Both numerical and analytic calculations for cyclotron damping relevant to maser emission show (a) that the effect is important only when the ratio of the mean energies of the thermal and maser emitting electrons exceeds 0.1 to 0.2, and (b) that some earlier treatments overestimated this damping. These ideas are applied to AKR, and the suggestions are made (a) that an o mode component may arise from partial reflection, and (b) that a second harmonic component can be produced. (Electron cyclotron maser, x-mode radiation, growth and damping rates.)
*Also from: School of Physics, University of Sydney, Sydney, NSW, 2006, Australia.
*Also Department of Astro-Geophysics, University of Colorado, Boulder, Colorado, 80309, U.S.A.
J. Geophys. Res., Space, Paper 3A1789

5765 Plasma motion, convection, or circulation
GEOS-2 IDENTIFICATION OF RAPIDLY MOVING CURRENT STRUCTURES IN THE EQUATORIAL OUTER MAGNETOSPHERE DURING SUBSTORMS
P. Robert (Centre de Recherches en Physique de l'Environnement Terrestre et Planétaire, CNET, 92131 Issy-les-Moulineaux, France), R. Gendrin, S. Perraut, A. Roux, and A. Pedersen
The ULF magnetic and the DC electric antennas operating onboard GEOS have been used to study the origin and characteristics of Short Irregular Pulsations (SIPs). By applying to the 3-component ULF signal a complex processing it is possible to demonstrate that most of SIPs are in fact the magnetic signatures of localized current structures passing by the spacecraft at a high velocity v. Very intense spikes in the electric field (E ~ 3-25 mV/m) are observed in connection with the passing over of such structures at the satellite location, but these E-field spikes are generally observed 10-20 s earlier than the SIPs. Provided that the duration of the magnetic signatures of the signal (2τ) is short enough (less than 2 s) it is possible to show that they correspond to Field-Aligned Current Tubes (FACTs) passing by the spacecraft. The direction of v can be deduced from the magnetic signature. In most cases this direction coincides with the direction of E×B. Then, by assuming that v = E×B/B², it is possible to compute the characteristic parameters of the structure: current density J, radius R and velocity v. The parameters which have thus been obtained are 6·10⁻⁷ ≤ J ≤ 10⁻⁵ A/m², 20 ≤ R ≤ 900 km, 15 ≤ v ≤ 170 km/s, with the following average values: J ≈ 4·10⁻⁶ A/m², 215 km, 70 km/s. When transposed to ionospheric altitudes these values are consistent with those found for localized field-aligned current structures by ground or low orbiting spacecraft observations. The origin and nature of these localized current structures are discussed.
J. Geophys. Res., Space, Paper 3A1791

5785 Whistlers
INTENSITY AND POLARIZATION CHARACTERISTICS OF WHISTLERS DEDUCED FROM MULTI-STATION OBSERVATIONS
I. Nishida (Institute of space and astronautical science, 6-1, Komaba 4-chome, Meguro-ku, Tokyo 153, Japan) and K. Tsuruda
Whistlers recorded at four stations along the geomagnetic meridian near Roberval, Canada on July 23, 1979 have been analysed. They showed a spatial attenuation rate as high as ~ 6 dB/100 km which is appreciably larger than previous theoretical predictions. The wave polarization of these whistlers was also analysed; the wave polarization was a maximum (right handed) at the station where wave intensity was a maximum. The wave polarization was also right handed at a station distant from the wave exit region. The locations of the wave exit region inferred from the intensity maximum were compared with the L-values of the whistler paths derived from the dispersion analysis. We obtained a consistent relation between them when uncertainties in the dipole field model are taken into account.
J. Geophys. Res., Space, Paper 3A1819

## Physical Properties of Rocks

6110 Elasticity, fracture, and flow
IMPLICATIONS OF JEFFREYS-LOMNITZ TRANSIENT CREEP
I. Strick (Department of Geology and Planetary Sciences, University of Pittsburgh, Pittsburgh, Pennsylvania, 15260)
The power law transient creep for rock as proposed by Jeffreys in 1958 is associated with a complex compliance having the mathematical form of a Schlömilch or Kapteyn hypergeometric function of the second kind with imaginary argument. An exact physical realizability is developed of a ladder network composed of springs and dashpots as the shunt step elements is developed, and the analytic complex compliance, attenuation, velocity dispersion).
J. Geophys. Res., Earth, Paper 3B1413

6110 Elasticity, Fracture and Flow
HIGH FLUID PRESSURES DURING REGIONAL METAMORPHISM AND DEFORMATION - IMPLICATIONS FOR MASS TRANSPORT AND DEFORMATION MECHANISMS
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Evidence is presented to support the conclusion that pore fluid pressures ($P_f$) during regional metamorphism are generally greater than or equal to the minimum principal compressive stress ($\sigma_3$). The resultant very low effective stresses (σ) lead to significantly increased porosity and permeability, even at moderate to high metamorphic temperatures. Permeabilities between $10^{-18}$ and $10^{-15}$ m² are considered to be common, resulting in rapid fluid migration and the dominance of advective over diffusive mass transport, even over relatively small distances. In view of the importance of intergranular mass transport to rock deformation during metamorphism, a mobile, high-pressure fluid may have substantial rheological effects, especially in polyphase rocks. The fluid is capable of influencing the rate of dislocation creep in a number of ways. More importantly, advective mass transport along fluid-pressure gradients can give rise to a solution-transfer deformation mechanism that competes with conventional pressure-solution. The rate of deformation by advective mass transport could be controlled by a number of processes, including dissolution kinetics, advective transport rates and the rate of crack growth. A specific deformation model, based on advective transport rate-control, is developed, which can produce strain at competitive rates, but with stress and temperature dependences of unusual form.
J. Geophys. Res., Earth, Paper 3B1803

6110 Elasticity, fracture and flow
ELASTICITY OF SINGLE-CRYSTAL ORTHOFERROSILITE
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The elastic moduli of $FeSiO_3$, orthoferrosilite, have been measured at 1 bar and 20°C by Brillouin spectroscopy. A comparison of the pyroxene crystal structure with elasticity data shows that distortion of the tetrahedral (T) chains parallel to c is related to $C_{33}$. Straight chains increase $C_{33}$ and highly kinked chains weaken the structure. However, the $FeSiO_3$ data show that beyond a certain degree of distortion the T chains are passive. $C_{11}$ is sensitive to composition as demonstrated by a positive linear correlation of $C_{11}$ with the size of the M1 octahedron (average M1-O distance.) The average longitudinal modulus $\bar{C}_{11}$ (($C_{11}$ + $C_{22}$ + $C_{33}$)/3), varies linearly with composition in the system orthoenstatite (En)-orthoferrosilite (Fs), whereas the average shear moduli $\bar{C}_{44}$ and $\bar{C}_{12}$ are constant to at least 20% $Fe^{2+}$. By contrast, the olivine solution Fo-Fa is consistent with a linear variation of modulus vs composition between the end-members for all three average moduli. We suggest that this difference between orthopyroxene (opx) and olivine is due to a preference of $Fe^{2+}$ for the M2 octahedral site in opx. The aggregate shear modulus, μ, is also found to be constant for opx containing up to 20 mole percent $Fe^{2+}$, even though μ is 30% lower for Fs than En. Despite a similar contrast in end-member values of μ, the olivine data are consistent with a linear variation of μ between $Fo_{100}$ and $Fa_{100}$. At high temperatures, $Fe^{2+}$ and Mg in opx will be randomly distributed and a linear variation of μ with $Fe^{2+}$ content is expected. A comparison of laboratory elasticity data with observed mantle properties shows that $V_p$, $V_s$, and ρ of the upper mantle are satisfied by pure olivine. The data also suggest that without the coexistence of garnet, no more than 10% opx may be present in a model mantle assemblage. Clinopyroxene increases the limit on mantle garnet content, but does not greatly affect constraints on the quantity of opx in the upper mantle. (Equations of state, properties of minerals).
J. Geophys. Res., Earth, Paper 3B1800

## Planetology

6530 Cross Properties of Planets
APERIODIC ION TEMPERATURE VARIATIONS IN THE IO PLASMA TORUS
Aharon Eviatar (Department of Geophysics and Planetary Sciences, Tel-Aviv University, 69978 Tel-Aviv, Israel) and Yuri Mekler
We consider the observed aperiodic variations of SIII temperature reported by ground-based observers, which take place on time scales short compared to the radiation and electron collision relaxation times. We suggest that ion-ion charge exchange processes are responsible for the heating and ion-atom collisions are the source of the cooling. We attribute the fluctuations to random strong variations in the output of neutral matter from the volcanoes and surface of Io. Freshly ionized sulfur which will have near full corotation gyroenergy will undergo charge exchange with thermal doubly ionized sulfur and oxygen, thus producing hot SIII. Newly injected neutral atoms can cool the ambient hot plasma by collisions on a time scale comparable to their lifetime against ionization processes. Analytic solutions of the temperature rate equations, including the time variation of the neutral and ionized matter density are found to reproduce the observed fluctuations for reasonable values of initial densities.
J. Geophys. Res., Space, Paper 3A1838 11/30

## Seismology

6970 Structure of the Crust and Upper Mantle
CRUSTAL STRUCTURE IN THE OROZCO TRANSFORM ZONE
Anne M. Trehu (Office of Marine Geology and Energy, U.S. Geological Survey, Woods Hole, MA 02543) and G.M. Purdy
Seismic refraction data from lines of small shots and from individual large shots recorded during project ROSE are used to determine the crust and upper mantle velocity structure in the Orozco transform zone. The objective of this study is to provide constraints on the origin of a deep north-south trending trough flanked by two shallow ridges. These topographic features are incompatible with the present plate tectonic framework as defined by the regional spreading direction (approximately east-west) and did not display any seismic activity during project ROSE. Travel times and amplitudes from a reversed profile along one of the ridges reveal an anomalous crustal structure: a velocity increase approximating a gradient of 0.5 sec⁻¹ extending through most of the crust and decreasing to 0.1 sec⁻¹ at the base, and a total crustal thickness of about 5.4 km. In contrast, three profiles from topographically normal oceanic crust indicate a crustal structure typical of oceanic crust throughout the oceans: a 1.5 km thick layer in which velocity increases from about 3 km/sec to 6.7 km/sec overlying a 4.5 km thick layer with a velocity of about 6.8 km/sec. The upper mantle velocity beneath both structures, determined from travel times from large shots at ranges of 30 to 100 km, is about 8.1 km/sec. These results are interpreted to indicate that the trough and flanking ridges represent an extinct spreading center that developed an axial valley as the spreading center progressively shifted to the present axis of the East Pacific Rise.
J. Geophys. Res., Earth, Paper 3B1731

6970 Structure of the crust and upper mantle
Pn TRAVEL TIMES IN SOUTHERN CALIFORNIA
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The Pn arrivals recorded from the Southern California Array have been used to demonstrate regional variations in crustal thickness, Pn velocity, and to investigate the presence of anisotropy in the mantle. Over 2800 travel times were used in the analysis. The classical time-term method was extended to allow the Moho velocity to vary in a block type structure. The statistical F-test shows these effects to be significant. Crustal delays determined depend on both crustal velocities and Moho depth. The Ventura and Los Angeles basins have significant delays which indicate sediment thicknesses near ten kilometers. The Moho depth itself varies by ten kilometers over southern California with a mean of about 28 km. Slightly thicker crust is prevalent in the northwestern corner of the array near the Santa Barbara Mountains. Five kilometers of rapid thinning between the coast and the Channel Islands is shown by a sharp gradient in the delay times. Normal crustal thicknesses occur over the rest of the array except for the area east of the Salton Trough, where an anomalously thin crust of 22 km exists. This area extends from near the plate margin into Arizona. While the Peninsular Ranges and the San Bernardino Mountains have small roots, the San Gabriel Mountains have none. Pn velocities range from 7.8 to 8.2 km/s within the array. High velocities are found in the Peninsular and offshore regions. Low velocities are found in the Transverse Ranges. The analysis supports the Transverse Ranges with the fast direction at N 75° W. This value represents an average of a parameter that varies considerably in the region.
J. Geophys. Res., Earth, Paper 3B1804

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